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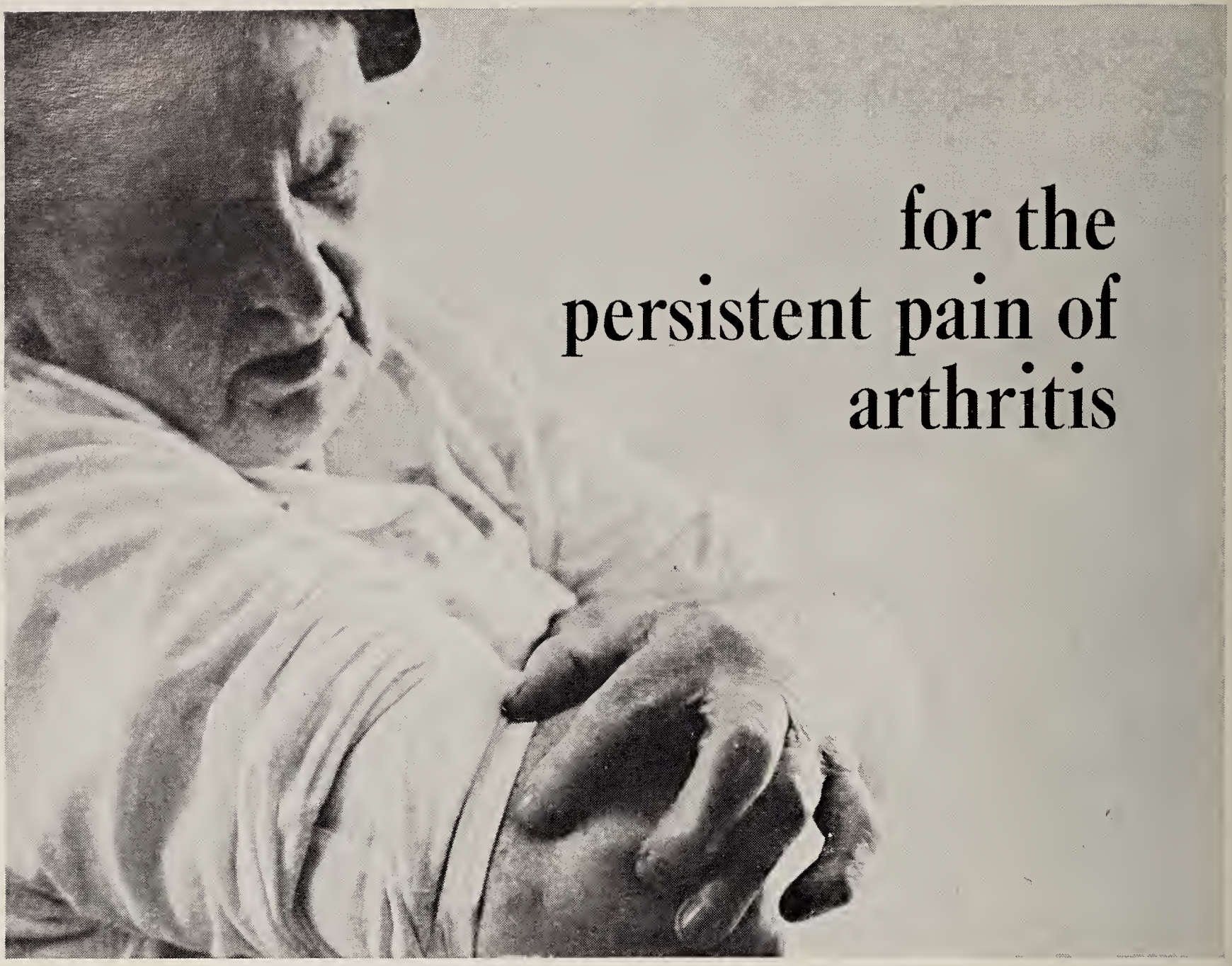

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Editorial

In Time Of Change

The house of medicine is in disrepair. Its rooms are overflowing with a growing population clamouring for more social welfare, its walls sagging under the burden of technological advances, its financial and educational foundations inadequate for the demands that have so rapidly been brought to bear. If we use patient care as the "yardstick of medicine", and in reality there can be no other yardstick, we are sometimes sadly disillusioned. Idealistic as his survey was, K. F. Clute found that only one half of Ontario practitioners give their patients satisfactory medical care.[1] Indeed as students we are constantly reminded of this by the continual references to the "Elsewhere General" and by the rampant lack of respect for the general practitioner. We are aware of unnecessary iatrogenic disease — for example, the incidence of aplastic anemia due to chloramphenicol may be as high as one case in 10,000 doses[2] and yet we still hear of it used in the initial treatment of minor ailments. In view of these failings it is no wonder that the laity regards medicine with a growing skepticism and distrust.[3]

The general practitioner is not to blame for inadequate medical care. He is practising medicine using drugs, techniques and concepts unheard of in his medical schools days; he has insufficient time or opportunity for proper patient care, adequate consultation, or further education.[3] The correction of this situation presents staggering problems in personnel and financial logistics. The need for physicians is so great that within the next five years Canada must double the number of its medical educators[4] and proportionately increase its hospital and research facilities and paramedical personnel. It is obvious that the expense of ideal medical care knows no bounds and therefore medical care objectives are necessarily limited by the proportion of funds that the government wishes to invest. Clearly it is impossible to meet these great demands overnight. Just as clearly, however, it is imperative that medicine and government work more closely in a reorganization of regional hospitals and medical care plans, and in a re-evaluation of educational and research facilities.[5]

Conservatism is an integral part of medicine, for a healthy and practised skepticism must be exercised upon the novel before it can affect the patient. Yet this should never lead to a fear of change or a distrust for innovation. And it should never degenerate into the "deadening traditionalism" that is attributed to Canadian medical schools by those research workers who emigrate to the United States.[6] There must be room for innovation or we must say with Koestler that "corporate orthodoxy has been the curse of genius from Aristarchus to Galileo, to Harvey, Darwin and Freud; throughout the centuries its phalanxes have sturdily defended habit against originality." [7] In the present time change is a necessity. But unfortunately change must approach the radical for "it will require more to meet the needs of the future than tinkering with the tools of the past."[8] We appreciate that this very radical nature of change is frightening for "there is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle than to initiate a new order of things." [9]

From Osler's time it has been reiterated that a doctor's education is a lifelong process. Yet the amount of time available for education in relation to the expanding volume of medical knowledge will always be grossly inadequate. Gradually it is becoming apparent that even a medical student's time has value, and that his time should be spent in the most educationally rewarding way. Taken to the extreme this philosophy might turn turn a doctor's education into a commodity produced in a medical school assembly line — the quantity and quality of the product determined by the efficiency of the educational machinations. The limits of the analogy are that the product, the doctor, must be more than an automaton; indeed the essence of his education rests upon his ability to exercise judgement based on knowledge and experience and tempered with a highly developed appreciation for humanity. This comes with the personal and individual practice of medicine — with this the medical student has too little acquaintance.

EDITORIAL

At present the natural evolution of medicine in North America has divided medical practice into two groups: the physicians of the teaching hospitals who practise, teach and investigate; and the suburban and rural physicians who practise family medicine and who refer their worst problems to the teaching centres. This larger second group of doctors faces the patient first, yet this is the group that is overworked and that is deficient in the new knowledge. These are also the doctors whom medical students never officially see, but whom the majority of them will join. For optimum medical care it is necessary to reduce the barriers between these two groups, to improve the educational opportunities among family doctors, and to expose students to community medicine. Toward this goal it is submitted that posting senior students for a time in suburban or outpost hospitals under the supervision of general practitioners would serve as an excellent stimulus both for the student to learn about family practice and for the practitioner to keep abreast of recent advances.

This special issue is in celebration of more than the centennial of our country. It points to the changes and advances in medicine to this day, and to the directions that medicine might take in the future. It represents our sincere applause for the beginning of change at this university — the foundations of the new medical building, the initiation of a new integrated curriculum, the establishment of an educational research unit, and the return of the general practitioner to the out-patient department. It represents our modest hope that this beginning will continue, and indeed that the concept of change will become an integral part of medical wisdom.

T.W.P. K.P.H.P. S.O.P.

REFERENCES

1. K. F. Clute, The General Practitioner, University of Toronto Press, 1963.
2. Editorial, Monitoring of Drugs, Lancet, Jan. 7, 1967.
3. Gross, The Doctors, Random House, New York, 1966.
4. Editorial, For Want of a Nail, C.M.A.J., Nov. 5, 1966.
5. Editorial, Motes and Beams, Lancet, Jan. 7, 1967.
6. Hesse and Fish, Canadian Trained Medical Scientists View Canadian Academia from their American Laboratories, C.M.A.J., Nov. 5, 1966.
7. Quoted by Croft in Learning the Medical Craft, Lancet, Jan. 1, 1966.
8. Miller, Medical Education Research and Development, J.A.M.A., 197: 162, Sept., 1966.
9. Machiavelli, quoted by Miller, op. cit.

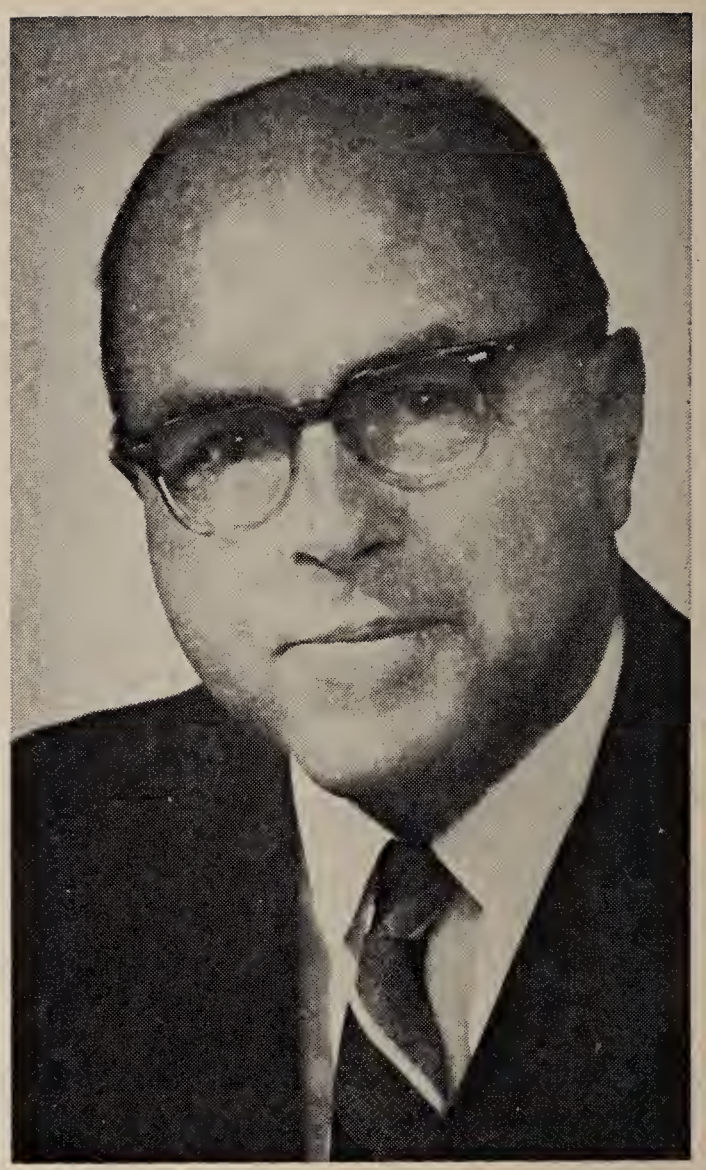
This final issue is one important in content but difficult in expression. We thus sincerely appreciate the thought and insight that the students have put into their articles. We thank our guest editor Dean Chute for his careful delineation of the new concepts of medical education that will come into being with the Medical Sciences Complex. For this issue, concerned as it is with the future of medicine, we have solicited several articles from people working at the interfaces of medicine and other disciplines. We are then indeed fortunate to have in this issue the generous and scholarly contributions of Professors Ausubel, Flowers, Llewellyn-Thomas, and Porter. We should like to acknowledge the advice and comment of Dr. J. W. Steiner and the financial assistance of the Medical Faculty Council in the production of this final issue. We should also like to congratulate Paul Manley on winning the Webster Prize for his article "A Holistic Concept of Medicine" which appears in this centennial issue.

Volume XLIV is the result of the work of many people. Our associate editors and contributors have made this journal truly "a medium of student expression". Special thanks are in order for our beautiful art editor, Miss Margot MacKay, and her staff — Bridget Hough, Liivi Kask, Valerie Haigh, Glenn Ried, and Marg Dennys — whose collective work has graced each issue. Thanks also go to David Dunn at the Princess Margaret Hospital for his photographical assistance and to our printers, the Maple Leaf Press, especially to Konrad and Roger for their evercheerful forebearance. Finally, to next year's editors Dave Legge and Bill Laird we extend our wishes for their success and our hopes that they will receive as much willing help on Volume XLV as we received during this year.

T.W.P. K.P.H.P.

Guest Editorial

ANDREW LAWRENCE CHUTE
O.B.E., M.A., M.D., PH.D., F.R.C.P.(C)
Dean of Medicine, University of Toronto



Dr. Chute was born in India in 1909; his father was a missionary and his mother a physician. He gained his B.A. at Victoria College and went on to obtain a M.A. in Physiology and his M.D. in 1935 with a Silver Medal. He interned at the Toronto General Hospital and held a residency at the Hospital for Sick Children. Thence he went to University College, London, to obtain his Ph.D in Physiology in 1939. He then served with distinction in the research division of the Royal Canadian Army Medical Corps. His research interests, accomplished on the battlefield and in the field dressing stations, were chiefly concerned with the physiological problems of tank warfare and with wound hemorrhage and infection. For this work he was awarded the Order of the British Empire. The war over, he became a resident at the New England Deaconness Hospital and specialized in diabetes and other endocrine disturbances. He returned to Toronto as a pediatrician and in 1951 became Chief of Pediatrics in the Toronto Hospital for Sick Children. Since 1960 he has been an active member of the Medical Research Council and Chairman of its Clinical Investigation Committee. Last year he succeeded Dr. John Hamilton as Dean of Medicine.

Changing Aspects of Medicine and the New Curriculum

The character of Medical Practice in recent years has been subject to many pressures both from within and without the profession. Some of the external pressures have been the public demand for prepaid care and increased access to both hospital and professional services. Public awareness of advances in medical science has demanded a high degree of sophistication in the type of service provided as evidenced by the assignment of strictly controlled professional privileges to all staff members of accredited hospitals. Internal pressures have been created by the need for prolonged and intensive training in order to provide the highly specialized care demanded. The increased tempo of scientific research in Medicine and increased opportunities in this field have removed "growing" numbers from the main stream of service oriented physicians. Higher standards for entry into Medicine have further accentuated this trend at a time when there has been a lack of facilities for expanding medical school enrolment to meet the public's demand for service.

Recent decisions to increase the facilities for teaching Medicine must therefore be coupled with curriculum changes to provide competently trained practitioners and scientists of the highest quality in adequate numbers to meet the demand. Over the past several years committee's of the faculty have spent many hours in studying the curricula of other schools obtaining briefs from our own departments and discussing the merits of various educational programmes.

The first major decision was made when it became evident that we were to have a new medical sciences building. There was a great deal of discussion as to its most useful location. Some felt it should be closely associated with a major hospital complex in order to integrate clinical sciences with the basic sciences. Others felt it was more desirable to have it located on the campus where it would share more fully in the academic and scientific life of the rest of the University. In typical Canadian fashion a compromise was reached in which the Medical Sciences Building is to be situated on the campus but will also provide considerable space for clinical scientists to carry out some of their research projects.

Before plans for the building were developed the basic science departments were urged to assess their curriculum with a view to making certain that the physical layout of the new building would assist and not hinder the teaching programme. Accordingly they settled on a plan of "Home based Laboratories". These consists of small rooms which accommodate a maximum of 16 students. Each student has his own desk and locker which are arranged around the periphery of the room while a large laboratory type bench occupies the centre of the room. Instead of students travelling around the building to laboratories in the various departments, the instructors will come to the student in his own laboratory.

Courses have been planned to interdigitate so that portions of a subject taught by different disciplines will be given in sequence and continuity, a plan which will be discussed more fully below. For rather obvious reasons gross anatomy cannot be accommodated by this device. Provision has been made therefore for this department's instruction to be given in its own area.

It is suggested that there should be some introduction of clinical material of an illustrative nature into the very first months of the medical curriculum. It is also recognized that a medical graduate should have some knowledge of the behavioural sciences e.g. Sociology, Clinical Psychology and Social Anthropology. Strong emphasis is placed on the importance of teaching principles and inducing students to be self sustaining in their learning experience rather than acting as passive vessels waiting to be crammed with facts. To foster this attitude it is planned to reduce formal teaching in order to provide the student with a block of time to study electives of his choice.

OBJECTIVES AND SCOPE OF THE CURRICULUM

These are summarized in the following:

(1) To fashion a climate for learning which will:

(a) develop the full potential of each student;
(b) endow the student with knowledge, skills, values, attitudes and professional and ethical principles basic to the furtherance of any career in medicine;
(c) instill a desire and capacity for continuing self-education;
(d) make the student constructively critical of all he sees, hears, or reads so that he may adapt the valid and discard the questionable;
(e) instill in the student a determination to provide conscientious care with scientific and clinical excellence without losing a sense of compassion and sympathetic understanding;
(f) make the student aware of the function and the need for co-operation with the other health, welfare and educational agencies in the community available to assist him in caring for his patients;
(g) make the student aware of his responsibilities not only to the individual patient but also to the community at large in terms of the socio-economic and cultural setting in which medical practice is carried on.

(2) To evolve a curriculum which:

(a) is an integrated unit and not a series of hurdles to be surmounted and left behind:
(b) presents an orderly progression of relevant information, knowledge and skills;
(c) emphasizes the interdependence of the biological, behavioural and clinical sciences;
(d) recognizes the variations of premedical backgrounds, individual interest of students and choices of future careers in medicine;

(3) To monitor and measure the performance of the curriculum by the best methods available, in order to assess its effectiveness in terms of the professed philosophy and objectives of the Faculty.

(4) To organize the Faculty in such a way as to allow for change in both Faculty organization and curricular policy as developments may require while ensuring all desirable stability.

(5) To involve students in the planning, conduct and evaluation of the curriculum.

(6) To organize the undergraduate teaching function in such away that (a) the staff of the departments will be able to continue effectively their scholarly pursuits and research, and (b) the graduate training programme shall be encouraged to flourish.

To implement this programme it is planned to organize instruction on the basis of subjects or systems (rather than based on conventional departmental lines). This will provide for the orderly sequence of instruction about any given system e.g. cardiovascular, respiratory, etc. going from the basic science through to the clinical application in each system.

Although the teaching of any one system may be spread over one to four years of the academic course three periods of major emphasis have been identified. The study of:

(a) Normal Biology of man.
(b) Mechanisms of Disease (altered human biology).
(c) Man with disease (i.e. patients).

For convenience these may be termed Period I, Period II and Period III.

PERIOD I

This period would be devoted largely to the study of normal structure and function—the sciences considered basic to medicine. These include morphological functional and behavioural science. The structure of the new Medical Science Building is predicated on covering the various divisions of anatomy as a block in the first 18 weeks. Subsequent to this a unified plan is proposed in which the presentation of all subjects would be arranged in a sequence leading from the most fundamental to the most highly integrated principles of the basic medical sciences. The latter part of the period would be devoted to a study of the normal function of systems, to their integration towards effective ends within the organism, and to the basic processes of pathology. These studies lead into and merge with those of PERIOD II.

PERIOD II

The study of systems and basic pathological mechanisms would emphasize the alterations of normal biological processes which cause or are associated with specific diseases. In the first period, as a part of behavioural science, the student would be introduced to social implications of illness and its impact upon the individual, the family and society. In the second period he would be introduced to the problem of disease itself—physical examination, history taking, etc.

It is envisaged that the time devoted to didactic and laboratory work related to patho-physiological mechanisms of disease would be approximately equal to that devoted to ward work. Ward work would occur in numerous hospitals. Without detailed planning it is impossible to estimate accurately the length of PERIOD II. It would extend from the second half of the second year to some time in the third year.

PERIOD III

This period is designated as a "clinical clerkship". In this period it is intended that a student will have real responsibility for patients under the supervision of the staff doctor. It is important to emphasize that the student is not expected to provide service to an unlimited number of patients but rather will be assigned each week a small number of patients whom he will care for and study in detail. Daily seminars and discussion groups with teachers and fellow students will be provided to aid him in his task and in the understanding of his patient's needs.

It is anticipated that the clerkship will take a full year instead of the academic 32 weeks and that students will be assigned for all instruction to an individual hospital for a block of time which may vary from 4 - 6 months, at the end of which they will move on to another hospital for a similar period.

If adopted this plan envisages discontinuance of the Rotating Internship. The first post graduate year would then become a first year straight residency in Medicine, Surgery, Paediatrics or family practice etc.

In order to accomplish teaching by systems instructors will have to be organized into appropriate groups. To accomplish this a chairman will be selected for each subject that is to be taught in any one of these periods. He will select appropriate teachers from any department to help him organize and teach his subject. If a subject is taught in two or more periods the chairman for this subject in each period will form a co-ordinating committee to ensure a logical progression of the subject from one period to the next.

It should be noted that for examination purposes it is proposed to employ comprehensive exams of the multiple choice type based on the work presented in the systems which have been covered prior to the time of the examination. Thus there will be no departmental exams e.g. Physiology, Biochemistry, Medicine, Obstetrics, Surgery, etc. though many if not all of these disciplines may be represented in the questions which are set.

It is natural that such a major change will require a lot of preliminary detailed planning which is going on at present. If it proves feasible the new curriculum will probably begin with the opening of the Medical Sciences Building in September 1969.

The Roots Of Our Medical School

R. Buehrle 6T9

DR. JOHN ROLPH

On March 4th, 1792, in Gravesend near Thornbury, England, a boy was born to Thomas Rolph, a surgeon. John Rolph's parents emigrated to Canada in 1807 and settled in Charlottville, Norfolk County, in 1810. John, however, remained in England for his education. There he studied both medicine and law. He joined his parents in 1812 but after a tedious position as paymaster to His Majesty's Forces in the London district he returned to England to complete his studies. Finally in 1821 he settled at St. Thomas, Ontario, where he vigorously pursued the practice of law. He was elected to the legislative assembly and became a bitter opponent of the Family Compact, that closely knit group of families who ruled the country.

In 1824 Dr. John Rolph wrote a letter to Col. John Talbot, founder of St. Thomas (once known as Talbotville). This letter marked the beginning of medical education in Upper Canada. It reads as follows:

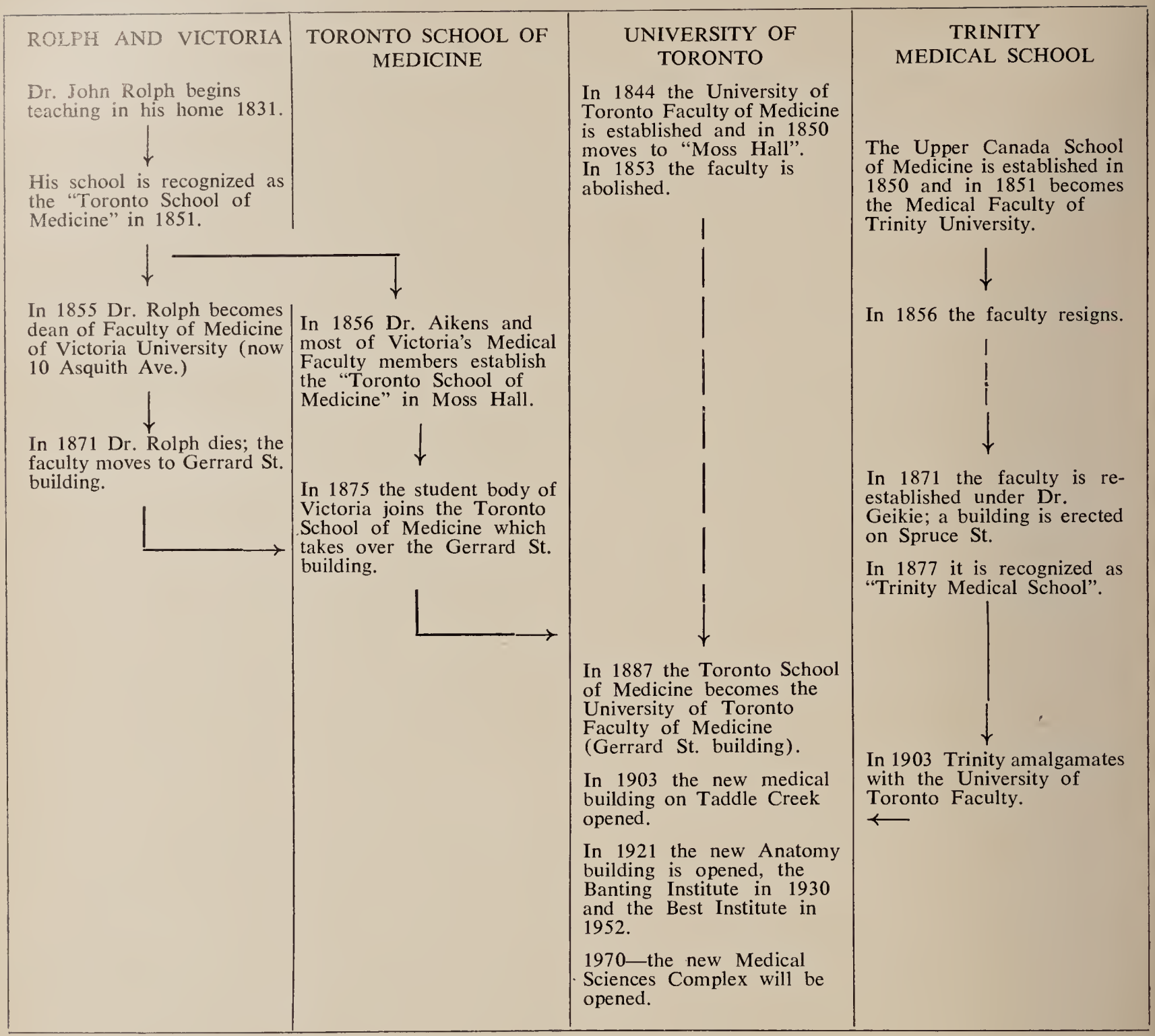
> My Dear Sir:
>
> Everything that is great and useful should begin in Talbot Settlement under your auspices. It was proposed by Dr. Duncombe more than a year ago, to form an institution at the City of St. Thomas for the instruction of candidates in medicine and surgery. No school of that description has yet been formed in any part of the Province nor is the hospital at York ever likely under its sleeping patrons to become a source of public usefulness.
>
> We propose to call it the "Talbot Dispensory". The Honble. Col. Talbot to be its perpetual Patron with visitorial Powers.
>
> Dr. Duncombe and myself will join our Libraries for the institution, which I am satisfied, will exceed very far any in this or sister Province. To it we will add other valuable works and periodical publications. To these I will add the anatomical preparations, which were the work of my labour, then a pupil of Sir Astley Cooper's.
>
> There will be about 12 pupils to begin with. . . ."

The school collapsed after two years, and Dr. John Rolph moved to Dundas, Ontario, to pursue his practice of law and medicine. Finally in 1828, dissatisfied with a legal decision he threw off his gown never to return to it. Soon after, he moved to York where he strongly participated in politics. In 1831 he began to teach medicine unofficially in his house on the site of the present new City Hall.

John Rolph was a radical and reformer at heart and he became a strong supporter of William Lyon Mackenzie. Even though he did not support Mackenzie in his rebellion in 1837, John Rolph was branded a traitor to Upper Canada and had to flee to Rochester for safety. His ability as a teacher can be judged by the fact that some of his students followed him across the lake to Rochester. Marion Patterson said of Rolph that:

> In the teaching of medicine Rolph had no superior and few equals. He had the whole field of medical literature at his finger tips and his graphic method of expression kindled the imagination of his students.

An Act of Parliament in 1843 granted amnesty to the rebels allowing him to return to York and he resumed his teaching in medicine with renewed vigor. His fame as educator grew so rapidly that in 1850 he was forced to add an addition to his home in order to accommodate all the students. Finally in 1851 his school was incorporated by an Act of Legislature as the "Toronto School of Medicine". As a second lecture hall they had to rent the Sunday School building on Richmond Street west from Knox Church (the pres-


ROLPH AND VICTORIA
Dr. John Rolph begins teaching in his home 1831.
His school is recognized as the "Toronto School of Medicine" in 1851.
In 1855 Dr. Rolph becomes dean of Faculty of Medicine of Victoria University (now 10 Asquith Ave.)
In 1871 Dr. Rolph dies; the faculty moves to Gerrard St. building.
TORONTO SCHOOL OF MEDICINE
In 1856 Dr. Aikens and most of Victoria's Medical Faculty members establish the "Toronto School of Medicine" in Moss Hall.
In 1875 the student body of Victoria joins the Toronto School of Medicine which takes over the Gerrard St. building.
UNIVERSITY OF TORONTO
In 1844 the University of Toronto Faculty of Medicine is established and in 1850 moves to "Moss Hall". In 1853 the faculty is abolished.
In 1887 the Toronto School of Medicine becomes the University of Toronto Faculty of Medicine (Gerrard St. building).
In 1903 the new medical building on Taddle Creek opened.
In 1921 the new Anatomy building is opened, the Banting Institute in 1930 and the Best Institute in 1952.
1970—the new Medical Sciences Complex will be opened.
TRINITY MEDICAL SCHOOL
The Upper Canada School of Medicine is established in 1850 and in 1851 becomes the Medical Faculty of Trinity University.
In 1856 the faculty resigns.
In 1871 the faculty is re-established under Dr. Geikie; a building is erected on Spruce St.
In 1877 it is recognized as "Trinity Medical School".
In 1903 Trinity amalgamates with the University of Toronto Faculty.

ent site of Simpson's Department store). Dr. Geikie, a student of Rolph, gave us a description of the first classroom:

> It may be interesting to recall here that when the number of students had increased so as to require more accommodation than an ordinary private house could furnish, the class-room first fitted up for them formed the end of a framed building in Dr. Rolph's yard. One part of this room had pine seats in it, ranged one above the other, while the table behind which Dr. Rolph and the other lecturers sat when they lectured was the vat for anatomical purposes. The rest of the room was provided with dissecting tables on trestles, and this constituted the dissecting room where a great deal of good dissection was done for a number of years. Only a thin wooden partition separated this medical college part of the building from the rest of it, in which where comfortably housed Dr. Rolph's horse and cow. So thin was this partition that while the medical students were drinking in their scientific knowledge as they listened to the lectures or were thinking or working at their dissections, the four legged occupants in the vary adjacent stalls, who cared little and thought less about anatomy, medicine, and surgery, could often be distinctly heard heartily enjoying their more substantial aliment.

In the same year that the school was incorporated Rolph returned to politics leaving the management of the school in the charge of his wife and his partner, Dr. W. T. Aikins who was a former pupil of his.

THE FIRST FACULTY AT TORONTO

Dr. John Rolph was not the only man who had realized the importance of medical education. A medical faculty had been discussed as early as 1828 but it had not been formulated. With the formal opening of the University of Toronto on June 8th, 1843 was born the first Faculty of Medicine. Lectures for the first two

officially registered students were held in 1844 in a wooden frame addition to the east wing of the old Parliament Building on Front Street. Six years later, in 1850 a medical building whose architecture was complementary to the first University College building, which stood at the site of the present day Parliament Building, was erected on the banks of Taddle Creek. Moss Hall, as it was called, was in 1888 replaced by the old Biology building which was demolished in 1966 to make room for the new Medical Sciences Complex. Since the University was a public institution it suffered from the censorious opinion of the populace. Thus it was that in 1853 the Hinks Act abolished the Faculty of Medicine and Law since as one taxpayer wrote:

> The decision reached by the legislature was the result of the common sense policy laid down and acted upon in regard to educating men for lucrative professions, with the cost of which, the members felt the country should have nothing to do. . . .

TRINITY BEGINS

In 1850 Bishop Strachan was approached by Drs. Bovell and Hodder with the request to affiliate their newly founded Upper Canada School of Medicine with Trinity College. In 1851 this school became officially the Medical Faculty of Trinity University. All three rival schools shared the clinical facilities of the Toronto General Hospital. Here one can see how religious feelings interefered with the pursuit of knowledge. Marion Patterson puts it as follows:

> Rivalry between the schools was keen. With Rolph's return to political life, as we have seen, he threw his energies into the challenge of Bishop Strachan and the Anglican claims respecting Clergy Reserves. Students of Canadian history know the length to which the feelings of the Anglican and the so-called dissenting Churches went. No one ran counter to Bishop Strachan without precipitating an active feud. Strachan made much of the Trinity Medical Faculty and they were influential men. In a short time they acquired control of the Toronto General Hospital. Rolph's political activities as a rebel had much to do with the anti-Rolph sentiment and had repercussions in the treatment given Rolph's students in the hospital.

The situation was so bad that Drs. Aikins and H. H. Wright were dismissed from the staff and were allowed to return only after they had resigned from Dr. Rolph's faculty. Furthermore this feeling of rivalry and general ill-will led to the closing of the Toronto General Hospital in 1868 for one year and was the cause of the loss of a young man named William Osler who had to seek clinical training elsewhere.

ROLPH AND VICTORIA

A year after the abolition of the Faculty of Medicine of the University of Toronto in 1854, Victoria University invited The Toronto School of Medicine to become

VICTORIA MEDICAL SCHOOL
Occupied from 1856 when Dr. John Rolph became Dean to his death in 1870 at which time a new building was erected on Gerrard St. East. The building was probably built in 1849-1850 as a church. Its present address is 10 Asquith Ave. near Bloor and Yonge Sts.

its medical faculty so that the students could receive a degree in medicine and not only to receive the licence to practise from the Medical Board. Rolph returned from politics in 1855 to become the dean of the faculty. Trouble soon arose between the autocratic dean and his colleagues, and thus at the beginning of classes in 1856 Dr. Rolph found himself without a faculty. But within two weeks this short and energetic man gathered around himself a new faculty among them W. Geikie a former student of his. The Faculty of Medicine of Victoria University under the deanship of Rolph moved to new quarters in Yorkville. This building still stands today on Asquith Avenue. The old faculty maintained the name of the "Toronto School of Medicine" after a court case, and set up the school in the old medical building on Taddle Creek, Moss Hall under Dr. Aikins.

Another setback to medical education occurred in the eventful year of 1856. Bishop Strachan wanted to dominate all facets of education and thereby caused ill-feelings and rebellion in the infant Faculty of Medicine of Trinity University. As a result the whole faculty resigned and the Trinity Medical School ceased to exist for the next 15 years.

Dr. John Rolph continued to dominate the field of medical education until 1870 when members of the staff suggested that he take on an assistant dean at which point Rolph's refusal forced his resignation. He died on October 19th of that year. With his death an upheaval took place in medical education. Dr. Geikie and others left Victoria University. Dr. Canniff, the new dean, tried to keep alive the faculty by erecting a new medical building at Sackville and Gerrard Streets near the old Toronto General Hospital; but, the spirit of the school had died with Rolph. On November 6,

1373, the whole student body went over to the Toronto School of Medicine and the Faculty of Medicine of Victoria University ceased to exist. The new building on Gerrard St. East was taken over by the Toronto School of Medicine.

THE TRINITY UNIVERSITY FACULTY

TRINITY MEDICAL SCHOOL

Built in 1871 when the medical faculty was re-established the building stands today on the south side of Spruce Street, west of Sackville Street. It was used until 1903 at which time the school amalgamated with the University of Toronto faculty.

In the spring of 1871 Dr. Geikie, who had left Victoria Medical School, suggested to Trinity University to re-establish a Faculty of Medicine. He was joined by others who had left Victoria and by some members of the original Trinity School. A new building was erected on the south side of Spruce Street near Sackville Street close to the General Hospital which occupied the block bounded by Gerrard Street East, Sackville Spruce, and Sumach Streets. In 1877 by Act of Legislature the school was incorporated as an entirely independent teaching body — "Trinity Medical School".

RE-ESTABLISHMENT OF FACULTY OF MEDICINE OF TORONTO

Many futile attempts were made towards the re-establishment of the Faculty of Medicine of the University of Toronto. "It was felt that medical students should have as sound a training in the sciences as possible and as this could only be obtained by their having free access to the laboratories and lecture rooms of an University such as that of Toronto." Standards were raised in 1882 and the graduating class dropped from 32 to 10. In order to remedy this, the University authorities invited the Toronto School of Medicine and the Trinity School of Medicine to become the re-established faculty. The latter school, however, rejected the offer unanimously. Therefore, in 1887 the Toronto School of Medicine became the Faculty of Medicine of the University of Toronto with Dr. W. T. Aikins as the first dean.

The amalgamation with Trinity Medical School occured in 1903 finally ending petty rivalry and ill-will and establishing a sound foundation for future medical learning and research. The amalgamation was not without casualties. Dr. W. Geikie, Dean of Trinity Medical School withdrew since he considered "amalgamation as extinction":

> "Huge facilities and huge classes cannot in the nature of things do justice either to individual lecturers or to individual students."

In 1903, the year of amalgamation, the new medical building was opened. Anatomy was taught in the upper floors of the Biology building next door until 1921 when the new Anatomy wing was attached to the Medical Building.

ANNOTATIONS

There is an old saying that the longer you can look back, the farther you can look forward. Let us then glance back and see what and how the art of healing was taught.

Those were the days of top-hats in which the doctors carried their wooden stethoscopes; of frock coats; of mutton-chop whiskers, or flowing beards; of pipe-smoking; and of that grave dignity of professors which kept students at a distance. Robert Koch first saw that red bacillus in 1881 but it was not until 1890 that W. Mulock, the vice-chancellor of the University, proposed to personally defray all expenses in order that Dr. Ramsey Wright could go to Berlin and become familiar with Koch's discovery. The idea that "germs" existed was accepted at face-value by the time the faculty was re-established, but most of the members had grave doubts concerning the importance of bacteria. During the repair of a fractured femur, a piece of silver wire was dropped on the floor. The intern suggested he get another sterile one, to which the senior surgeon answered: "Oh never mind give me the first one. The "bugs" haven't had time to get on it yet".

The student body was, as a rule, older than to-day but their extra-curricular activities were far from sedate. They livened up that morbid subject anatomy by inviting an organ-grinder and his monkey to provide entertainment while they worked. The students sang a lot, mostly hymns, the words however were of their own choosing. It seemed that the students of Trinity Medical College decided to liven up Meech's Meat Store on Parliament Street, a fashionable street in 1890, by suspending a freshly pickled cadaver from the meat hooks. It is said that his business was rather dead for the next few weeks. Finally, in 1920 Dr. C. K. Clarke, the dean at that time, instituted "Daffydill Night" as a less barbarous outlet and for many years he played his fiddle in the orchestra.

The struggle of women entering medicine is a book in its own right. Up to 1906 no women were allowed to register in the Faculty of Medicine. On June 17, 1904, a very confidential letter was sent to the Faculty Council reporting a rumour that a woman was attempting to enroll in the third year. That fall the Faculty drew up a resolution that women cannot under any circumstances register in the Faculty of Medicine. Nevertheless, two women did register under the pretence of wanting to take only Anatomy, which at that time belonged to the Arts subjects. In 1906 the Faculty permitted female students to register as full-time medical students but tuition was carried out in separate classes. Three years after the first two women registered, the Faculty benignantly stated that "henceforth women would be considered exactly on the same footing as men and that no distinction be made." It is of interest to note that Miss M. L. Menten, one of the first two women to register, received the Reeve Scholarship for her graduate work.

Fees in 1900 went up from $85 to $100 which was quite high considering that most people earned under $15 a week. Student enrollment was around 250 from 1887 up to the amalgamation with Trinity when it rose to 450. In those days professors did not receive a salary but rather a percentage of the yearly profits graded according to the number of lectures he gave. In 1903 the entrance requirement was raised from 33% at matriculation to 40% and the medical course was extended from 4 to 5 years. There were still some students who were working on their matriculation while studying medicine.

These tangled skeins, unravelled after careful study of many dusty archives, provide this fascinating story of medical education from its inception in Upper Canada to the present day. Stretching away into the future —What new patterns are forming?

ACKNOWLEDGEMENTS

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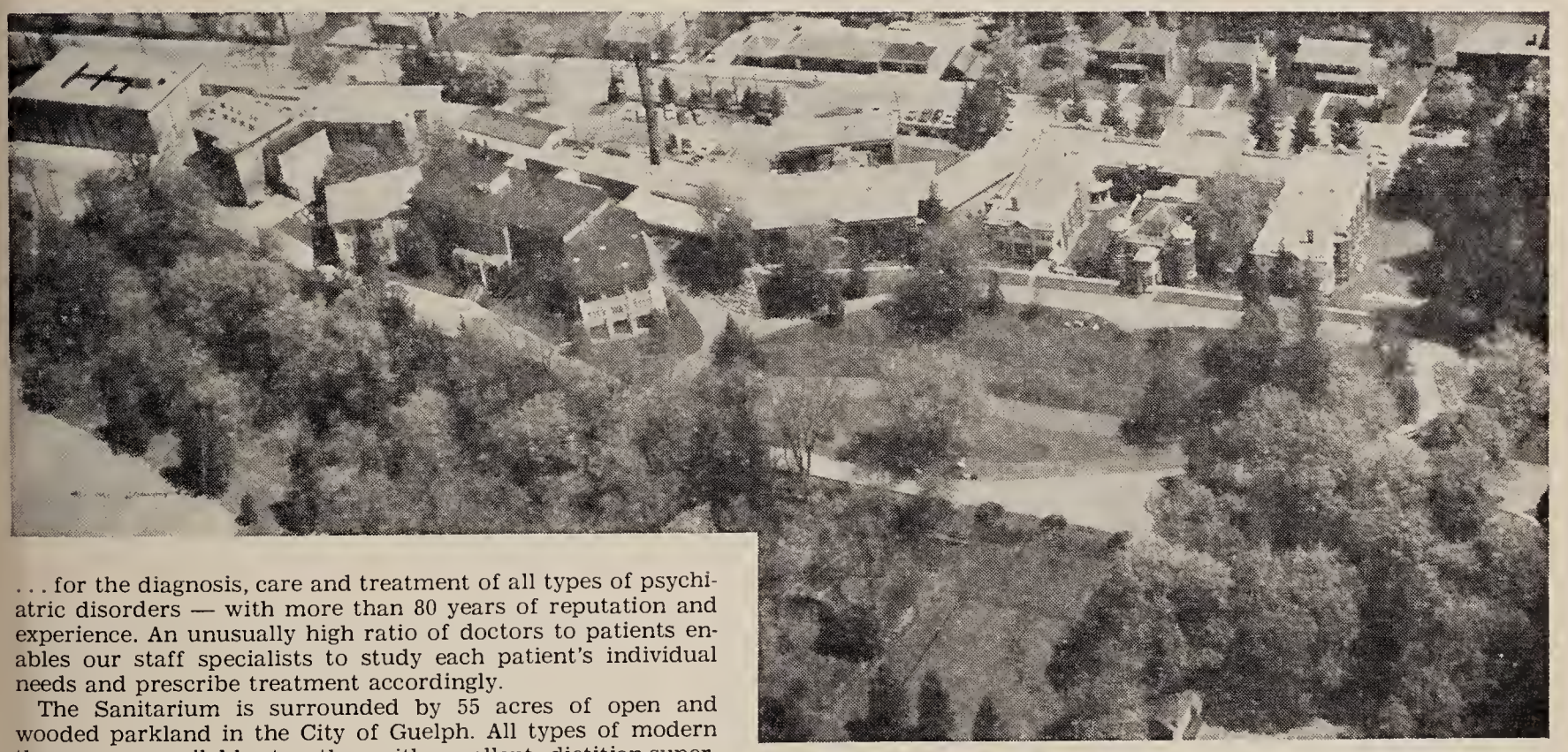

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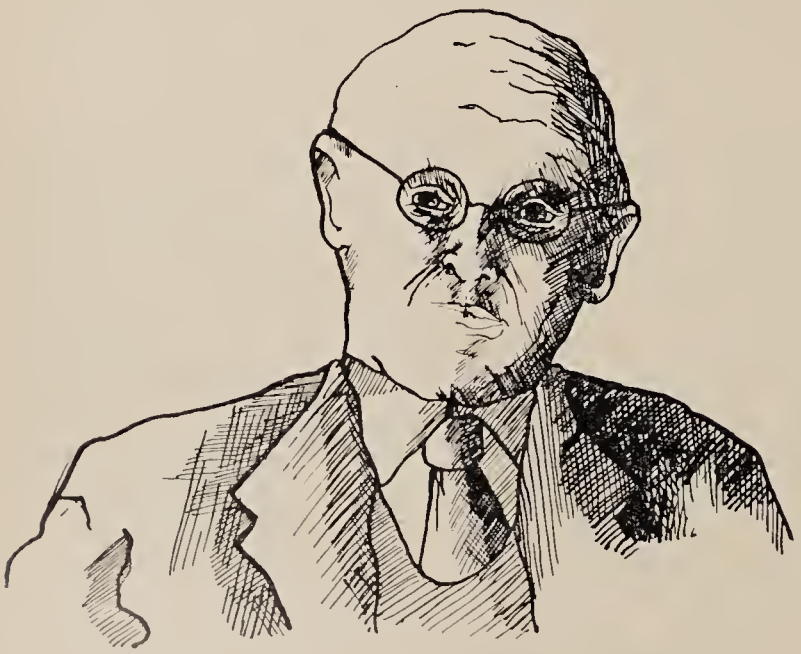
Medical Education: The Legacy Of Abraham Flexner

K. P. H. Pritzker 6T7

"Toronto alone, . . . has developed a system of "optionals". During the first three of the six years, the Toronto students carry their fixed regular program year by year and day by day. Every year there are open spaces in the time table which they are compelled to fill up; in the first medical year one option must be exercised among cultural subjects; in the second and third, one cultural and one scientific subject must be chosen, a dubious and probably ineffective device. During the last three years, students who "have attained a certain standing in the courses of the first three years" are permitted to follow options annually in any of a large number of fields of study. Those who have not made good records previously are obligated to take a "review" or "repeat course". Though the final choice is largely left to the student, he is warned against aimlessness, and a faculty member is designated to assist him in reaching an intelligent decision. The authorities are obviously eager to stimulate the capable to do more work, and more fundamental work, but they are evidently of the opinion that the Canadian student is far from ready for academic freedom even in the domain covered by the optional courses; he is still forced to do stipulated amounts annually, rather than held accountable for larger achievements performed more or less in his own way, at the close of longer and varying periods." [1]

"Other marks of the old fashioned schoolmaster are present. . . . Toronto for example sets up a total requirement of 5,945 hours over six years." [1]

—*from* MEDICAL EDUCATION *by A. Flexner, 1925, p. 145*



The name Flexner to most physicians may recall (if it does that much) a kind of gram negative bacillus known to be an occasional cause of dysentry. Abraham Flexner however, was neither a bacteriologist nor even a physician but a former Kentucky schoolmaster; yet his work profoundly affected the nature of medical education throughout the world. This is but a modest statement of Flexner's contribution, all the more remarkable in the light that the story of his life reads like an academic's Horatio Alger dime novel, literally rags to international fame. Born in 1886 in Louisville, Kentucky, Abraham was the sixth child of nine; his father, Morris, was a Bohemian Jewish immigrant who eked out a living as a wholesale hat pedlar. Young Abraham attended the Louisville public schools, worked part-time in the local library, and with the financial aid of his brother Jacob, a drug store owner, entered Johns Hopkins University (1884) to study classics. After graduating, he returned to teach at the Louisville high school, and later at his own private preparatory school. With the encouragement of his wife he gave up teaching school for graduate study at Harvard (1905). There he pursued psychology, philosophy, and science, studying neuroanatomy on the side under his brother Simon, (the bacteriologist of the bacillus, and the first director of the Rockefeller Institute).

This was followed by a year in Europe studying higher education, and the publication of his first book, *The American College*, a criticism of teaching at Harvard. Among the very few who read this book was H. S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching whose views of education at Harvard were in concord with Flexner. By a fortunate coincidence, on his return to the United States in 1908, Flexner applied to Pritchett for work.

Now, at this time, public concern was rapidly mounting about the deplorable condition of American medical schools; many were just profitable diploma mills. Pritchett, impressed with Flexner, commissioned him to study individually, the 147 medical schools in the United States and the 7 in Canada. His report, Bulletin number 4, of the Carnegie Foundation for the Advancement of Teaching (1910), revealed that of the 155 schools, only 50 required high school for entrance; only 50 were integral parts of universities; 139 schools had only part-time teachers and inadequate or nonexistent libraries and laboratories. Flexner recommended

that the number of medical schools be reduced to 35, that these schools be well endowed with full time professors, and that the schools be geographically well distributed. The immediate impact of the scandal aroused by the report closed down 89 schools.

But the long-term consequences were even more far reaching. First, Flexner was asked to visit the European schools for the same purpose, and his report, Bulletin number 6, was published in 1912, but with far less dramatic results.[2] Next, the Rockefeller Foundation, interested in improving medical education, approached Flexner for ideas on how best to spend the available funds. Flexner suggested giving the money to Johns Hopkins which was already in a position to become a model medical school; $1,500,000 was promptly endowed for full-time clinical teachers. Later, through Flexner's efforts, the Rockefeller Foundation earmarked $45,000,000 for medical education. In addition to the Rockefeller's, he wrangled millions out of such tycoons as George Eastman, J. P. Morgan, and the Whitney family to establish and improve medical schools. By the time Flexner retired in 1928 from the General Education Board, the granting body, it was estimated "that he secured for medical schools no less than a total of $100,000,000".*

Flexner was "immensely industrious with a strong sense of dedication, perhaps rather humourless." His penchant for accurate detail is nowhere better seen than in the above description of the Toronto curriculum in 1925. (The irony of his words in these days of curriculum change needs no elaboration.) His brilliant talent, and although he despised the word, superb training, qualified him perfectly for that peculiarly mid-twentieth century title—educator. Here is Hans Zinsser's eloquent tribute, "Oh Abraham Flexner, we have fought with you on minor points, have alternately admired and disliked you, have applauded you for wisdom and detested you for opinionatedness. But in just retrospect, layman as you are, we hail you as the father, or, better, the uncle of modern medical education in America."[5]

Flexner, "retained a sense of wonder that an obscure second generation American could find the opportunity to do so much". He achieved so much because of his personality; but his enormous influence on the philosophy of medical education was deeply coloured by the very fact that he was "by culture a German, by profession a schoolteacher".[2] Impressed with the efficiency of the German laboratory and English bedside teaching, he endorsed the view of Karl Ludwig and Franklin Mall that medicine should be taught in university hospitals staffed by full time men whose prime concern was teaching and research. He firmly believed that medicine was about to take its place among the "hard" sciences such as physics and chemistry. With the aid of his enormous financial support, Flexner's ideas on curriculum, clinical teaching, and research gained wide acceptance throughout North America.

FLEXNER AND CURRICULUM

Flexner's thoughts on curriculum structure are representative of his philosophy and most interesting. He was aware of correlative forms and he asked,

> "Is it not possible to contrive that the different threads, anatomical, physiological, pathological, etc., will be interwoven as [the student] proceeds?
>
> "The first of these suggestions proposes to attain this end by regional correlation under which the student would take up simultaneously the anatomy, physiology, etc., of successive regions—head, thorax etc.; a second proposes correlation by systems. . . . students would take up the anatomy, physiology, etc., of successive systems (e.g. respiratory, circulatory); a third proposes correlation on the basis of disease. . . . Thus, the curriculum would be composed of a series of stories, each the story of the edifice as built, fitted out with its appropriate anatomy, physiology, biochemistry, pathology, clinical medicine or surgery." [1]

But, he vehemently opposed formal correlation of medical subjects. First,

> "Such reorganization would involve an enormous increase in administrative complexity. Is it not clear that the administrative burden will be greatly increased at the cost of the pitiful fragments of time and energy now left to the staff for research and teachings?" [1]

This claim is supported by a somewhat fatuous footnote,

> "It [correlation] was as a matter of fact, dreamed of by an impractical Austrian emperor as far back as 1786." [1]

Secondly, he felt that with curriculum correlation teachers would be selected with regard for "their capacity for . . . team play." The scientists involved would concentrate on the applied medical aspects of the subject and would neglect the independent ideas of the "pure" science. This statement was based on Flexner's belief that the sciences were entities unto themselves to be studied solely for their own sake.

> "The sciences in question (anatomy, physiology, etc.) are fascinating pursuits organically complete as such . . . and would be properly so described were there no such things as medicine and surgery at all." [1]

*Flexner's contributions were far from over. In 1928, he delivered the Rhodes Trust Memorial Lectures at Oxford. An expanded version of these lectures was published as *Universities — American, English, German* wherein he roundly criticized the universities and proposed as a partial solution, the creation of the small institute for advanced research. No sooner was this published than he extracted $8,000,000 from Louis Bamburger, a department store magnate, to found the Institute for Advanced Study at Princeton. Flexner directed the Institute from 1930 - 1939, securing as its first professor a refugee by the name of Albert Einstein. Flexner wrote his autobiography *I Remember* in 1940 but lived on to the age of 93. (1959)

Thirdly, he claimed that correlation would be spoon-feeding and thus hinder the student.

"Not the most ingenious dovetailing and correlation that can be devised will save the student from the necessity of [reviewing his studies] throughout his professional life. Sheer repetition in one form or another . . . thus only does one learn."

His ideal of learning was that of the individual teacher who would "correlate" his own subject, and by his masterful presentation, inspire the student towards further inquiry.

Similarly, he discussed early exposure to clinical experience only to dismiss it,

"One hears with increasing frequency nowadays another dubious suggestion, that early experience in the clinic would stimulate the student to study the basic sciences.

"A mixture of the two viewpoints (pathology, physiology, and clinical diseases, therapeutics) if deliberately undertaken for the purpose of buying the students' attention . . . is surely unsound.

"The early introduction of the clinical demonstration . . . deals with so inconsiderable a body of details that it is bound to be futile. And the effort may be rather worse than futile for while the student is getting a firmer grip on a few associated anatomical, physiological and clinical facts, the infinitely larger mass of anatomical and physiological data . . . may all the more readily and entirely drop out of memory."[1]

In short, to Flexner, attempts to facilitate the learning of medicine were an irrelevant waste of time,

"Far more wholesome would it be to admit once and for all the difficulty of learning medicine and the impossibility of teaching it."[1]

* * *

Today, nearly sixty years after his first report, all of medicine remains deeply indebted to Flexner. Therefore, to comment on Flexner's legacy is to be placed in a position very much "like a Neanderthal man attacking a mastodon with a bean-shooter".[4] With some trepidation then, a few points concerning curriculum shall be ventured. First, Flexner's deliberations are a salutary reminder that the major curriculum concepts (and arguments pro and con) have been clearly outlined for at least forty years. Yet large scale attempts at curriculum change such as at Harvard, Western Reserve, and now Toronto have occurred only in the last ten years. Perhaps because of the almost unbounded magnitude of his contribution, both material and philosophical, Flexner's influence was so great as to be undue. Most North American schools adopted his curriculum pattern holus bolus and this pattern has stood freezing in its rigidity for the past forty years. Finally, Flexner cared little for the form of teaching, "systems of education stand or fall by virtue of effort and ideas, not machinery."

Sheer enthusiasm and originality in teaching is not to be ignored, but what Flexner did not realize is that the mode or form of organization is imprinted on the mind every bit as much or more as the content. Sciences are considered no longer separate entities isolated in knowledge-tight compartments. Indeed, any science, any compartment, whether it be anatomy or molecular biology or whatever is a mere (subjective) way of looking at and ordering boundless spectra of phenomena for our convenience. As a case in point, different observers visualize the cell as a red and blue mosaic under the microscope, or a quite different black and white one under the electron microscope, or as patterns of enzymatic processes, electrical charge, ionic concentrations, osmolar gradients, molecular sequences, subatomic interactions, etc. In reality, the cell is at the same time each of these, all of these, and none of these, the observations dependent on the techniques employed. Correlative overviews free observations and hypotheses from the bondage of rigid, systematized doctrine, and thus facilitate fresh insight. This is the essence of Claude Bernard's experimental medicine; why should it be denied to the medical student struggling to order his own knowledge? Moreover, learning from these compartments is fraught with the risk of imprinting useless patterns on the mind. For example, disease is first learned as pathology and disordered physiology, an abstraction of the condition as observed in the patient. Then, when the time arrives to consider disease in a particular patient, it is this abstraction which is the basis of the student's judgement. Is it not better to confront the medical student with the problem in toto, by exposing him to patients occasionally from the time he commences the study of basic science?

How much preferable it would be to develop modes of learning flexible enough to excite the student to observe, read, and investigate, to expand his perspective, to encourage his humane approach, and to mature his judgment! These goals themselves were Flexner's, but to achieve them attention to the forms of learning is essential; the key, flexibility. Some forms currently considered, options, correlation of lectures, preceptorships etc. are a beginning. What these forms will actually turn out to be remains undefined, but their purpose should be to nourish the students' aptitudes and sustain his motivation, or at the very least not to stifle these precious qualities. For medical education, this is at once the crux of the problem and the challenge.

REFERENCES

1. Flexner, A.: Medical Education, Macmillan, 1925.
2. Miller, H.: Fifty Years After Flexner, Lancet No. 7465, Vol. II for 1966, p. 647, Sept. 24, 1966.
3. Parker, F.: Abraham Flexner (1866-1959) and Medical Education. J. of Medical Education, Vol. 36, p. 709, 1961.
4. Zinsser, H.: Rats, lice, and History. p. 21 Bantam Books, 1960.
5. Current Biography 1941, p. 289, H. W. Wilson Co., New York, 1941.

*A Modern Philosophy Of Medical Education**

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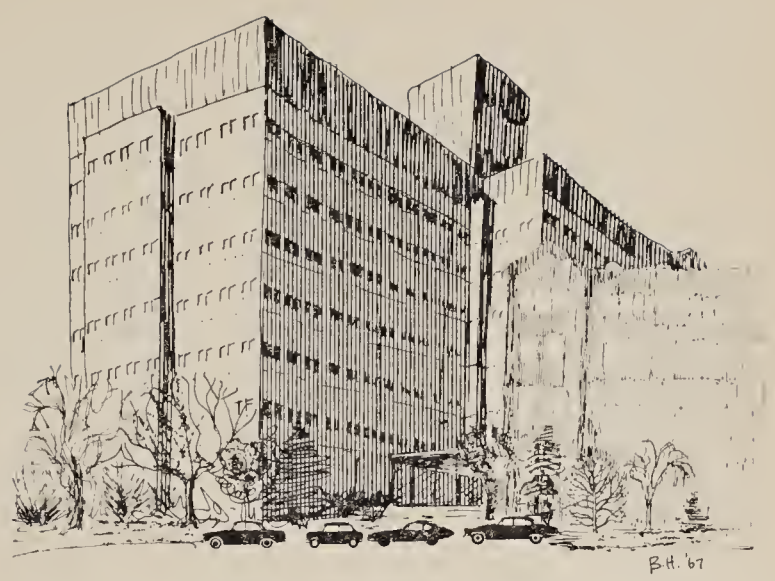

MEDICAL SCIENCES BUILDING
This is a view from Queen's Park of the Medical Sciences Building now under construction at the University of Toronto. This building will house over four hundred scientists and cost in the neighbourhood of forty million dollars. The old Anatomy Building (1921) is on the right.

It is generally agreed that medical schools have two principal and equally important functions: (a) to make significant contributions to medical science, and (b) to train practitioners of medicine and medical scientists. Strangely enough, however, a curious double standard tends to prevail with respect to these two objectives. In regard to the discovery of new knowledge in medicine, rigorous empirical evidence is invariably invoked to confirm or disconfirm any hypothesis or theoretical proposition. But insofar as the validation of principles and techniques of medical education is concerned, the relevance of factual and experimental data is typically disallowed. Thus, whereas the medical scientist is continually striving to improve and validate diagnostic and therapeutic techniques in the various medical specialities, and to enhance his understanding of the mechanisms underlying different disease entities, in his role as educator he seems quite satisfied with static and only reasonably satisfactory methods of instruction in medicine, without demanding any objective evidence of their actual merit or inquiring into how and why they work.

Hence, for hundreds of years, medical education has enjoyed an anomalous position in the science of medicine. On the one hand, it has been generally accepted that progress in medical science is largely a function of empirical research in applied biology. But at the same time, in the training of physicians and medical scientists, the diametrically opposite position has been adopted, i.e., that decisions regarding the selection and evaluation of students, the content and organization of the curriculum, and the proper role and form of laboratory, lecture, and bedside teaching can be validly made without recourse to research data on medical education. As a result of this anomaly, while tremendous advances have been made in both the basic science and clinical aspects of medicine, progress in the science of training physicians effectively has been relatively negligible. Apart from improved administrative practices and the adoption and enforcement of formal standards, no fundamental change in medical education, based on objective evidence regarding the learning and retention of medical knowledge, has occurred since medieval times.

Any modern approach to medical education must be concerned with at least the following seven issues. First, there is the crucial problem of selecting the most promising candidates for admission to medical school. We know that success in medicine presupposes superior intellectual ability of a particular sort, sustained motivation over a lifetime, and an uncommon degree of professional dedication. Yet, in selecting students, we rely principally on only such general indicators of academic ability as school marks and nonspecific tests of academic ability, weighted intuitively along with unreliable and subjective information from questionnaires, interviews, and principal's recommendation. Urgently needed are more specific measures of the *particular* kinds of intellectual ability that are important for success in medicine (e.g., ability to comprehend medical material, diagnostic inference ability), as well as relevant measures of interest, attitude, personality, and motivational status. It is also important to validate these measures against both success in medical school and success in different career choices such as general practice, specialty practice, research, and teaching.

Second, more valid ways of evaluating student performance must be found. This means measuring the kinds of skills and competencies that we are trying to teach in medical school and that we expect students to exhibit in the practice of medicine. At the present time, we test principally for factual knowledge and not very validily either, since any reasonably verbal and motivated student can pass our examinations by rotely committing our lectures to memory. With a little ingenuity it should be quite possible to devise examinations that simulate the conditions of medical practice and test the student's abiity to interpret data, to seek additional relevant information, to make warranted diag-

*Paper presented to the Clinical Curriculum Conference, University of Toronto Faculty of Medicine, Guild Inn, Scarborough, October 17, 1966.

nostic inferences, and to propose rational therapeutic measures.

Third, there is the crucial problem of integrating and promoting transfer between the different levels of medical instruction, namely, the premedical, the preclinical, the didactic clinical, and the practical clinical. We know that there is an organic relationship between these four levels, but because of the way in which the medical curriculum is organized, students typically fail to perceive the relevance of the premedical and preclinical years for later clinical instruction. Thus, means must be found to introduce as much clinical material as possible into premedical and preclinical subject matter. By making a deliberate effort to unify the subject matter of medicine, instead of teaching it in separate air-tight compartments, it is possible to integrate the structural and the functional, the normal and the pathological, the macroscopic and the microscopic, the contemporaneous and the developmental, the preclinical and the clinical, the lecture hall and the laboratory, didactic instruction and bedside teaching. In this integrative effort, the subject matter of pathology — macroscopic, microscopic, and clinical—plays a key role. Properly used, the clinical-pathological conference can become the cornerstone of an integrated medical education. We may also discover that it would be highly advantageous to defer much of the detailed content of anatomy, physiology, and pathology until the clinical years, when their relevance for clinical practice is more apparent to the student.

Fourth, recent discoveries in the psychology of learning and in the teaching of mathematics and science have important implications for the improvement of didactic instruction in medicine. We need to explore the challenging opportunities inherent in the sequential organization of subject matter, the use of key organizing ideas, progressive differentiation of subject-matter content, integrative reconciliation of related topics, prior consolidation of ongoing knowledge before introducing new material, and the provision of early and differential feedback. Since a good textbook can present the established knowledge of a discipline much more efficiently than a series of lectures can, new uses must be found for lecture periods. We must also explore and validate new methods and media of teaching medicine such as programmed instruction, computer-based instruction, and the selective use of educational television for certain designated objectives.

This brings us to the fifth major porblem, namely the medical textbook. Undergraduate textbooks in medicine are perhaps the most poorly organized, badly written, and most unreadable in any discipline. We urgently need a new, integrated series of undergraduate textbooks in medicine that conform to what is known about the psychology of learning and follow the model provided by recent textbook series in mathematics, physics, chemistry, and biology.

A sixth important problem is the improvement of laboratory instruction. Much laboratory work in medicine is a form of traditional busywork that has little educational value. For example, is there really any sound reason for spending three hours of laboratory time in demonstrating the muscle-nerve preparation, apart from hallowed medical tradition? Laboratory work should be reserved more for the teaching of scientific method in a medical context and for learning useful laboratory skills rather than wasted on cook-book exercises, on demonstrating the obvious, and on presenting principles that could be transmitted more effectively on an expository basis.

Seventh and last, medical education must be concerned with increasing our knowledge of the diagnostic process and with finding ways of enhancing diagnostic ability. Although diagnostic acumen is the key competence in medicine that distinguishes the truly outstanding physician from his less able colleagues, we know practically nothing about its nature, its determinants, and its trainability. We don't even know how to identify and measure it reliably and validly. Are good diagnosticians born or are they made? Perhaps it's not an all-or-none matter, but one of discovering which components of diagnostic ability are trainable and which are not.

To summarize, the essence of a modern philosophy of medical education, in my opinion, is the belief that progress in medical education presupposes the same reliance on empirical research as does progress in the basic and clinical sciences. We can no longer delude ourselves that adequate instruction in medicine follows automatically from knowledge of subject matter alone, or that knowledgeable professors necessarily make effective teachers. Principles of effective instruction in medicine can be discovered only through painstaking empirical research.

Faculties of medicine deal with a product no less than does Chrysler Corporation or General Motors. The sole difference is that our product is medical education rather than automobiles. The only possible way of ensuring quality control over our product is to maintain a systematic program of evaluation and educational research. At any given point in time we have to know how effective our educational program is, and we can only measure this in terms of the extent to which the knowledge and performance of our students conform to our educational objectives. Hence, both faculty and students must learn to welcome regular and systematic testing rather than to regard it as a threat, an intrusion, or a distraction from more important matters. And, if we hope to improve our product, we must be willing to experiment with new techniques of selecting and instructing students, always subjecting these techniques to rigorous empirical evaluation.

Surgery - A Viewpoint

M. Schwartz 6T7

1731 is an important landmark for both barbers and surgeons.[1] In that year Francois de la Peyronie, famous for his description of the disease that bears his name, founded the Royal Academy of Surgery in Paris and thereby established as two distinct disciplines the tonsorial art and the art of surgery. I have chosen, in this essay, to writé about surgery. What follows is one man's journalistic impression of present day surgery and its future.

Surgery today is quite different from what it was the morning that William Morton, a second year medical student at Harvard, informed the professor of surgery that he could proceed with the first operation on an anesthetized patient.[2] Modern operating room nurses enforce with a vengeance the principle of antisepsis that Lord Lister proved,[3] and all surgical patients benefit from the advances that these two discoveries made possible.

Every bit as important as the surgical advances *per se* are the improvements in the so-called adjuncts of surgery; the life support systems, the diagnostic tools.

As never before, surgeons are aware of and able to control conditions in the internal milieu of the patient before, during and after surgery. Heart function can now be augmented by a portable heart and lung bypass machine which can be hooked up to the femoral artery and vein in five minutes.[4] In this way, a critically ill patient can undergo more definitive diagnostic procedures while awaiting surgery. Cerebral aneurysms can be more safely dealt with under controlled conditions of hypotension and hypothermia.[5] In the old days, postoperative patients returned immediately to the wards to recuperate from their surgical ordeal in relative privacy. Today, poked, probed and carefully monitored, the patient in a modern recovery room has less chance to die unnoticed.

Better diagnostic procedures allow the surgeon to individualize his operative procedure and select more accurately those patients who will respond well. Exfoliative cytology,[6] radioactive scanning techniques and the like afford earlier diagnosis of a host of conditions. As a result, fewer patients undergo operations they cannot withstand or operations they do not need. However, in spite of our present day technological armamentarium there is a great variety of conditions which remain inadequately treated and the development of certain surgical subspecialties, in terms of therapeutic effectiveness has lagged behind that of others.

In surveying the surgical subspecialties, it is possible to judge their relative sophistication by considering the degree to which surgeons in a particular field have forsaken, as a primary objective, the restoration of normal anatomic structure and by assessing the effectiveness with which they have been able to manipulate the structurally abnormal part to restore more normal function. In other words, the most advanced disciplines are those in which physiology has most completely superceded morphology in the assessment of disability and in the planning of therapy.

Where the functioning units of a system are large and few in number and where the action performed is more obvious, for example, the movement of a joint or the flow of fluid past a valve, surgeons have been extremely successful in altering structure so as to ameliorate function. Two fields where good understanding of physiology and considerable technical virtuosity have combined to produce dramatic results are the surgery of the hand and of the heart.

Muscles which normally activate less important digits can be made to operate the thumb and index finger of a damaged hand by reinsertion of their tendons in new positions. Pedicle flaps of skin, blood vessels and nerves can be swung from other parts of the hand to restore sensation to these two digits.[7] Thus, an imaginative surgeon can produce a useful hand by seeming disregard for normal anatomic structure.

Likewise, a baffle of tissue is placed inside the heart of a person with transposition of the great vessels to correct the functional defect where a more anatomic solution would have been to retranspose the vessels.[8]

However, for obvious reasons, in systems where the functional unit is small and where many units operate in parallel, progress has been much retarded. The major plumbing in cardiovascular and urological surgery has been accomplished. But, as yet, the manipulation of renal parenchyma has largely been limited to extirpation of abnormal tissue which embarrasses by encroachment

or threatens by infiltration the remaining healthy functioning portion of the organ.

It is a fact that the installation of a new heart valve or a urinary diversion procedure[9] is a reprieve from death. It cannot be denied that these procedures are significant advances in surgery. But, I believe that these developments historically will be considered refinements of our present era and do not represent the vanguard of surgical progress.

Similarly the advances of microsurgery which are revolutionizing the surgery of the ear[10] are also products of the present and will ultimately be limited in their application by the therapist's inability to deal individually with a million nephrons or neurons. Nobody would suggest that multiple chromosomectomy will someday be the treatment of choice for Downs' syndrome.

It is often claimed that advances in immunology will usher in the ultimate era in surgery. It is probable that the immunological information that will enable us to adjust the body to reject cancer cells as foreign will also permit us to adjust the body to accept homologous transplants as replacements for defunct parenchymatous organs. It is likely that "spare-parts" surgery will soon become a practical reality. However, it is my opinion that this approach will never be more than a stop-gap measure and that the problem of what to do about inadequate lungs or kidneys or undesirable lumps will be solved in a different way.

I believe that the future of surgery in a broad sense will be the effective physicochemical manipulation of the tiny functional units in parenchymatous organs and the control of single cells. The ends to which we will perform our surgery will be at least to enhance the function of existing tissue and at most to promote the regeneration of new parenchyma. The means whereby this manipulation will be performed will be relatively gross. The prototypes of this style of surgery are already in use.

An example of a surgical act that enhances the function of existing tissue is the surgical treatment of Parkinson's disease.[11] The basic defect, it is postulated, is a degeneration of the substantia nigra. It has been experimentally shown that further lesions placed in the thalamus and the basal ganglia abolish, at least temporarily, the incapacitating tremor and rigidity. Although there is no regeneration of new parenchyma, our lesser aim is realised.

Two operations which achieve a measure of regeneration are vagotomy and pyloroplasty for peptic ulcer[12] and the innominate osteotomy for late correction of congenital dislocation of the hip.[13]

In performing the former procedures the ulcer is of secondary concern and is generally left *in situ*. Of primary concern is the physiological readjustment of nervous and mechanical stimulation of acid secretion which permits the mucosa to heal. The innominate osteotomy uses a knowledge of some of the factors that affect the growth and development of bone. The relationship of the acetabulum to the femoral head is changed by slicing through the pelvis and wedging the ischium and pubis downwards. In this way, the abnormal growth patterns that produced the abnormal joint are reversed.

What do these procedures have in common? They are imaginative manipulations of the organism designed to alter the environment of cells. But, their limitations are obvious. The operation for Parkinsonism induces no new growth, the vagotomy and pyloroplasty permits the regrowth only of mucosal cells and the osteotomy can only be performed on the growing child. As yet, There are no procedures which will initiate the useful regeneration of nerve cells, liver parenchyma and the other more complex tissues.

As I have suggested, the chief problem of surgical concern is that of growth and regeneration. Why are surgeons, as opposed to other medical specialists, especially suited to deal with this matter? Because it is the surgeon who has the special manual skills required to solve the difficult problems that arise in the conduct of experiments in living animals and because at present his inability to induce growth or regeneration confronts him daily in clinical practice.

Those subspecialties which are most advanced therapeutically are either those which are least dépendent on regrowth, that is, where prostheses or transplants work best, or those, like the setting of fractures where functional healing occurs. Tumours with a good prognosis are the slow-growing ones. It is the neurons that do not regenerate, the alveoli that are irrevocably destroyed and the wild neoplasms that stymie the surgeon.

For these reasons I believe that the future of surgery depends on the better knowledge of cellular function and its control, and that the ultimate goal of surgical research must be the understanding and regulation of growth.

REFERENCES

1. Garrison, F. H.: History of Medicine, Fourth edition, W. B. Saunders Co., 1929, p. 393.
2. Ibid., p. 505.
3. Ibid., p. 590.
4. Heimbecker, R. O.: An Address to the Academy of Medicine, Toronto, December 12, 1966.
5. Marshall, B. M.: Clinical Neurosurgery, 9: 142-9, 1963.
6. Pearson, F. G. and Thompson, D. W.: Canad. Med. Ass. Journal, 94: 825-33, 16 Apr., 1966.
7. McGregor, I. A.: Fundamental Techniques of Plastic Surgery, Third edition, E. S. Livingstone Ltd., 1965, p. 207.
8. Mustard, W. T., et al.: J. of Thor. and Card. Surg., 48: 953-958, Dec., 1964.
9. Campbell, M. F.: Urology, Second edition, W. B. Saunders Co., 1963, pp. 2449-2466.
10. Decroix, G. and Deguine, C.: Ann. d'Otolaryngologie et de Ch. Cervicofaciale, 83: 335-347, Avr.-Mar., 1966.
11. Gurdjian, E. S.: Operative Neurosurgery, Second edition, Williams and Wilkins Co., 1964, pp. 190-191.
12. Zimmerman, L. M. and Levine, R.: Physiologic Principles of Surgery, Second edition, W. B. Saunders Co., 1964, pp. 505-513.
13. Salter, R. B.: J. of Bone and Joint Surg., 48-A: 1413-1439, Oct., 1966.

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A Holistic* Concept Of Medicine

P. Manley 6T7

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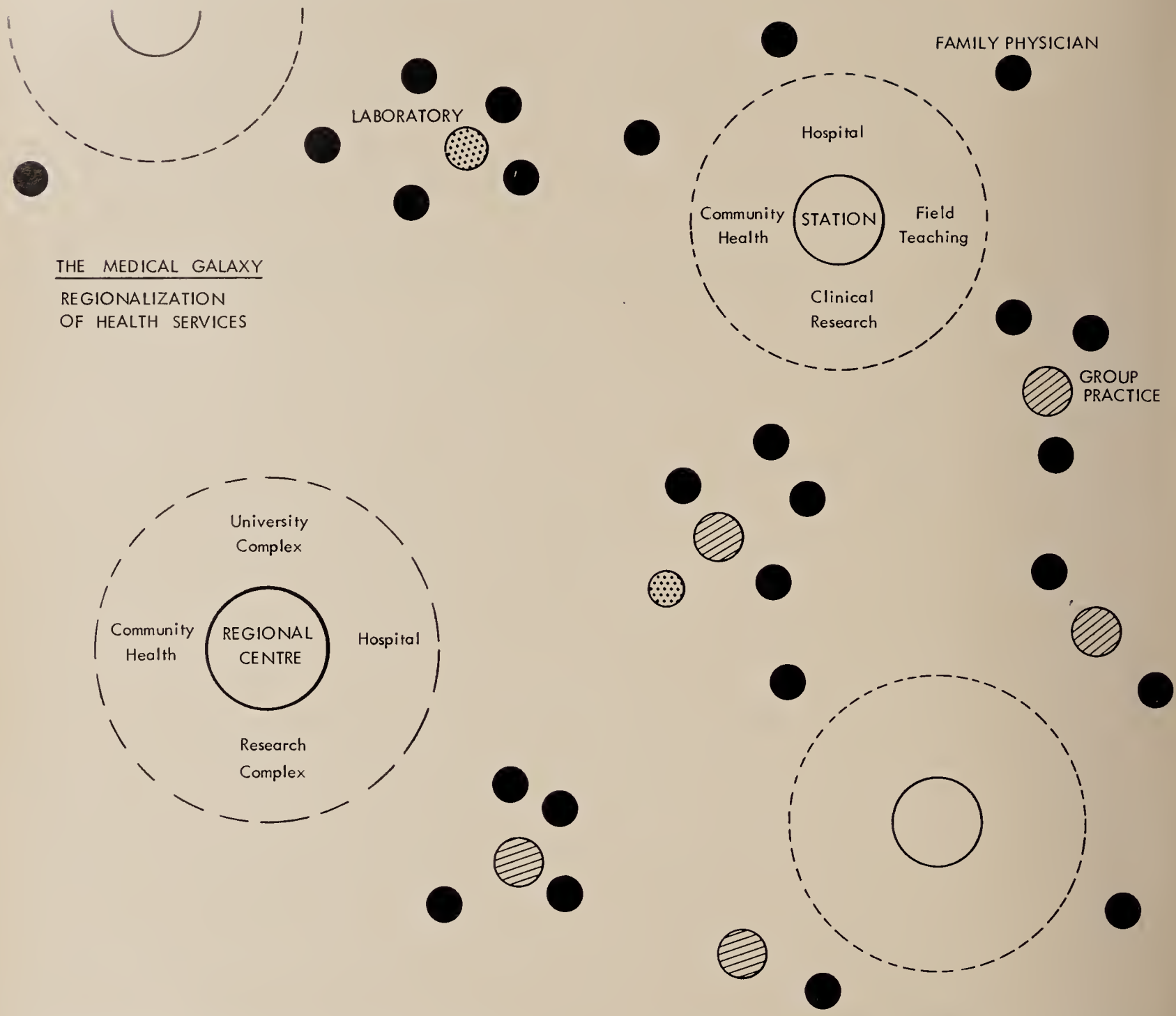

THE MEDICAL GALAXY

REGIONALIZATION
OF HEALTH SERVICES

The rapid technological and scientific developments in medicine have produced a paradox, for within the fabric of their great triumphs is woven the pattern of even greater challenges. The progressive struggle against infectious diseases and diabetes has relatively increased the morbidity and disability in those very areas in which medical science is still least effective—chronic and geriatric illness. Indeed Anderson and Rosen have stated, "If the leading causes of death in an area are heart disease and cancer . . . the area has kept abreast of modern medicine and its application." [1] The demand on medicine is further accentuated by the soaring health expectations of the public stimulated by the mass media, the increase in disposable income and availability of insurance plans, and the promise by our future "Great Society" of the equal distribution of excellence in medical care.

Secondly, the advancing technology is gradually transforming medical care from an individual profession to a highly organized and institutionalized industry turning out a much better product but at greatly increased costs. This has fermented the pressing problems of medicine today: the increasing capacity of medicine overwhelming the individual, the trend towards hospital or group practice, the relation of specialist to family physician, financing and administrative difficulties and the changing character of the doctor-patient relationship.

*[illegible]osophic theory that an object has a reality other than [illegible]d greater than the sum of its constituent parts.

The solution to these challenges is complex; it involves much more than medical financing and extends through a comprehensive reorganization of health facilities and medical education to quality evaluation. But "far reaching decisions will be made and quickly because now the combination of money and mandate are uniquely persuasive."[2] To sustain effective control of comprehensive health care, medicine must adopt a new professional role and help initiate the appropriate progress.

NECESSITY FOR CHANGE

Current medical care quality encompasses both the magnificent and the abysmal. K. F. Clute in his survey of general practitioners found that only 51 per cent of the Ontario sample and 26 per cent of the Nova Scotia sample practised medicine of satisfactory quality; he had grave misgivings about 28 per cent of Ontario and 52 per cent of Nova Scotian practitioners.[3] In the United States four fifths of the hospitals have no interns or residents—forty per cent do not meet minimum standards.[4] The same is undoubtedly true of Canada. The magnificent in North American medicine tends to obscure its underlying mediocrity. Canada, while enjoying the world's second highest standard of living, is now eighth on the list of life expectancy trailing the Scandinavian countries and the Netherlands by greater than three years. If our infant mortality rate was identical to the Netherlands some four thousand lives would be saved each year.[4 5] Our deficiencies are not due to a relative lack of medical staff; our doctor population ratio is 1:860, compared to the Netherlands 1:900.[6] In the Netherlands the difference is perhaps wooden shoes and exercise or the national availability of the best in medical care.

REORGANIZATION

Our problem then is to insure a more equal distribution of medical facilities and to decrease the gap between current medical knowledge and its application—all within an efficient coordinated system. Such an attempt was made in the United States by the members of the President's Commission on Heart Disease, Cancer, and Stroke in 1963.[7] They recommended a regionalization of medical services.

Across the country in sites of existing medical excellence a network of "regional centres" would be established concerned with active patient care, research both clinical and fundamental, and education. By strengthening and integrating existing resources, they would incorporate all the newest and most effective tools for diagnosis, treatment, and rehabilitation. Supplying the centre would be a ring of peripheral "stations" situated in existing medical centres and community hospitals. Their function would be multiple; to provide emergency surgical care and diagnostic screening facilities to determine referral to the more highly technical centres. They would be equipped to comprehensively handle the broad spectrum of disease especially in chronic or terminal disorders, rehabilitation and preventive measures not requiring the advanced diagnostic and therapeutic facilities of the regional centre. A continuous 24 hour per day seven day per week specialist consultant service would be available to the family physician. To coordinate and improve community services within large urban areas the commission recommended "a broad and flexible program of grant support whereby university and medical schools and other health care and research agencies and institutions work in concert". The program is intended to encourage flexibility with health care organized regionally to meet the specific needs of the region. In Canada these regions may be either within the provinces or economic-geographic areas, as the Maritimes, Quebec, Ontario, Prairies, British Columbia and the Northern Territories.

MEDICAL EDUCATION

Servicing such a network of medical facilities will require the efficient utilization of an increased number of personnel, both paramedical and medical. Training of the medical staff should be consonant with their future roles. Three broad categories of learning should be instituted—the family physician, specialist-consultant, and clinical scientist.[8] Each should take a medical core curriculum lasting perhaps three years and then proceed to their postgraduate training.

1. THE FAMILY PHYSICIAN

He should be prepared to provide initial and continuing comprehensive care to the individual and family. His training should include the social sciences, and care of the ambulant patient and should be conducted in a setting simulating office practice—perhaps the regional station. His status need not be a passer of the buck. S. Wolf had a much loftier view: "He will see the patient first and shall be the diagnostician, evaluator and analyst of data and the counselor of the patient. He will rely heavily on us technologists of medicine . . . or second class physicians located in centres at least 30 miles apart, surrounded by costly and impressive equipment plugged into digital computers. . . . The man in the field, my new kind of G.P. will be the really first class physician."[9]

2. SPECIALIST-CONSULTANT

His role will be to provide excellent care in a specialty or subspeciality. He will function in a hospital or group setting mainly as a consultant to the family physician and not as the first line personal physician.

3. CLINICAL SCIENTISTS

He should combine highly advanced training in both a speciality and basic science. Mainly he will be situated in the regional centre working in concert with basic scientists and specialist-consultant.

Such a division of roles prompted an Australian dean to say, "The day of the medical giant is largely over, and a whole team-Lilliputian hallucinations in the eyes of some of our great predecessors, no doubt — now takes the field."[10] The expanding organizational needs of health care, now the third biggest industry in North America will also require a highly trained imaginative administration and an unprecedented cooperation between all health care personnel.

FINANCING

The cost of such a health care program is quite low when compared to the total health expenditure in Canada—$2,562 million in 1966 or 5.5% of our Gross National Product. The Hall Commission suggested that only a 5 - 11% increase in Health's share of an expanding G.N.P. to perhaps 6 - 6.5% over five years (1966-71) would provide the necessary financial base for comprehensive health care. It is true that education, housing, roads, etc. are also competing for public funds. All are probably sound investments for future economic growth. However, the loss to the nation from illness is outstanding; estimates vary from one billion dollars per year in Canada from mental disorders and diseases of the circulatory system to 24 billion dollars in the United States from heart disease alone. Perhaps medicine may also achieve a more personal purpose "to enlarge human freedom—to set people free, so far as we can, from the disability and suffering that so easily mar their lives and hamper their fulfillment."[11]

CONSEQUENCES OF REGIONALIZATION

1. IMPROVED LOCAL CARE

Each region would possess the facilities and personnel to insure excellent care to everyone within the region. There would be an unimpeded pipeline from the vast store of medical knowledge passing through the regional centre, regional station and consultant to supply the family physician.

2. EFFICIENCY

The system would encourage collaboration regionally, discouraging some of the senseless competition and duplication in urban centres where institutions are often concerned more with their own excellence, than with community care. Extremely advanced and expensive surgical units such as cardiology and neurology should be assembled in only one or two regional centre hospitals. This would give adequate patient volume for a broad surgical training experience and allow more regular use of costly technical facilities. Such concentration has been very successful in radiotherapy. Home care programs and chronic care wings which demand less intensive diagnostic and nursing attention could release the general hospital to concentrate more on definitive diagnosis and treatment. Rehabilitiation facilities and personnel could then focus on the chronic care wings and chronic care hospitals.

3. INCREASED RURAL INVOLVEMENT

The attractiveness of the community hospital would encourage greater local enlistment in medical training and slow the flow of personnel to the larger centres.

4. CONTINUING EDUCATION OF THE FAMILY PHYSICIAN

The failure of the intense continuing education programs in the last twenty years was documented in the Clute study; despite the recent insistence on early diagnosis in cancer less than one third of the physicians examined the breast when it was appropriate or indicated; after ten years of literature on the use of the antimicrobial agents nearly one third "demonstrated so little knowledge in the use of antibiotics and the sulfonamides that they were given a score of zero." Clute concluded his study by stating, "in the long run, the recipient of medical care may benefit less from the elucidation of an obscure and rare disease than from a better organized and more thorough application of existing knowledge."—perhaps a dig at the abundance of programs on "Recent Advances". Continuing education in common with our entire eduucational system assumes that exposure to the learned and their gospel assures learning. But "students are alive and the purpose of education is to stimulate and guide their self-development."[12] The family physician working out of a community hospital has the necessary environment, full facilities and stimulating atmosphere of consultants and fellow physicians. He can learn by acting at the "field" level.

5. PREVENTIVE MEDICINE

Facilities and personnel would finally be organized for a thorough screening of the population for presymptomatic disorders with a regular follow-up programme. Cytological screening may decrease the incidence of squamous carcinoma of the cervix from 28 per 100,000 to 4 per 100,000 a great saving in future life and expense.[13]

FUTURE DEVELOPMENTS

1. COMPUTERS

Data processing in medicine will rapidly become a necessity. Intricate medical records may be conveniently stored and instantly recalled from all over the country. Research in clinical methods and epidemiology will be facilitated. The itinerant patient will enjoy continued rather than renewed care. Computers have already surpassed specialists in the reading of E.C.G.'s and E.E.G.'s. Their success in clinical diagnosis laboratory diagnosis and therapy proposals is surely imminent. The success of future medicine still rests however with the practitioner for garbage* fed into a computer yields only garbage.

*bad data

2. QUALITY EVALUATION

To maintain a constant improvement in medical care, its quality must be continually reassessed. Currently, quality evaluation is formally used in four areas:

(i) *Medical education*—where examinations are the arbiters of competence.

(ii) *Surgery*—where all surgical specimens are examined by a pathologist to determine if perhaps a normal appendix was removed during an attack of porphyria.

(iii) *Accreditation committees*—to determine if medical schools and hospitals are maintaining a national set of standards.

(iv) *Record-review studies*—by reviewing hospital or clinical records they may determine infant mortality, five-year survivals or incidence of dyspepsia following plantar wart removal.

With the aid of a computer, statistics acquired from hospital records could yield comparative information on diagnostic acumen, efficacy of various treatments, and cost studies. This service would in no sense be punitive but would inform hospitals about their performance with the expectation that this data would help augment the quality of their care. Such a study of blood transfusions by the Commission On Professional and Hospital Activities in the United States revealed laboratory difficulties and the excessive use of single pint transfusions.[14] This study initiated changes resulting in improved patient care and the economy of an overall diminution in blood used. Evaluations of individual practitioner care could indicate necessary areas of emphasis in postgraduate education. Quailty evaluation programs must procede delicately. They should not be associated with a 1984 aura of intrusion and regulation but regarded as a sincere attempt to scientifically examine our methods and results and to benefit from them.

3. SOCIAL CONSCIENCE

Medicine should develop a broader social role where its specialized knowledge can help decrease the problems caused by the rapid industrialization and the rise of the city. Positive advice and encouragement would help regulate air and water water pollution and their consequences, e.g., chronic bronchitis and carcinoma of the lung. Industrial design could recognize and utilize the physiology and temperament of the blue collar worker. Urban planning could consider not only aesthetics but psychology as well. Intelligent comment on divorce and abortion would hasten needed legislative reforms. Perhaps medicine would regain the same sagacious reputation that the proverbial personal physician once enjoyed.

FINAL SERMON

In the introduction to the Secular City, Harvey Cox states, "The rise of urban civilization—became possible in the contemporary form only with the scientific and technological advances which sprang from the wreckage of religious world views."[15] So too, paradoxically, modern medicine may only rise like the phoenix from the ashes of a narrow dogma—the view that medicine constitutes solely an inviolable 1:1 relationship between patient and doctor. Physicians must adopt a broader social role—one that sees medicine as a community, national or even international interaction as well as the vital individual one.

All facets of medicine should finally discard a portion of their introversion and address themselves constructively to the broad concepts of comprehensive health care. Discussion however must be fertile. To paraphrase J. F. Galbraith: to proclaim the need for new methods has served in some measure as a substitute for instituting them.[16] A beginning can be made. All creative change may be initially disruptive—this should not deter us from instituting an organized program to help us realize our basic aim—an excellence in medicine shared by all.

REFERENCES

1. Somers, H. M.: Doctors Patients and Health Insurance, The Brookings Institution, Washington D.C., 1961, p. 9.
2. Sanzaro, Paul J.: An Agenda For Research in Medical Education, JAMA, 197: 149, 1966.
3. Clute, K. F.: The General Practioner, University of Toronto Press, Toronto, 1963.
4. Gross, M.: The Doctors, Random House, New York, 1966.
5. Royal Commission on Health Services, Vol. 1 & 2, 1964, Queen's Printer, Ottawa.
6. World Health Organization—World Directory of Medical Schools, Geneva, 1963.
7. President's Commission on Heart Disease, Cancer, and Stroke, 1963.
8. Evans, J. R.: The Clinical Teaching Unit as an Effective Organization For the Education of Residents under Changing Medical Socio-Economic Circumstances. Canad. Med. Ass. J., 95; 720, 1966.
9. Wolf, S.: Quoted in ed. Medical Education and Medical Care, New Eng. J. Med. 226; 520, 1962.
10. Andrew, R. R.: The Plan of the New Medical School, Monash Univ., Med. J. Aust. 25: 940, 1965.
11. Fox, Sir Theodore: quote from editorial, New Eng. J. Med., 274: 161, 1966.
12. Whitehead, A. N.: The Aims of Education, New American Library, 1964.
13. Editorial: Cytology in the Detection of Early Carcinoma of the Uterine Cervex, Canad. Med. Ass. J., 96; 282, 1967.
14. Medical Care, Ed. I. J. De Groot, Charles C. Thomas, Springfield, Ill., 1966.
15. Cox, H.: The Secular City, MacMillan Co., New York, 1966.
16. Galbraith, J. K.: The Affluent Society. Pelican Books Suffolk, 1958.

Aspects Of Intercultural Medical Practice

J. A. Friedman 6T9

Marie Vigil is a young Spanish-American mother living with her children in a single room in the Mexican district of Los Angeles. She has an early case of tuberculosis. She feels well and cannot understand the need for hospitalization or the hazard she is to her family.[1]

For Marie Vigil and millions of people in diverse yet similar circumstances, preventive medicine and its scientific basis is unintelligible. Understanding by non-westerners* of this scientific basis of medicine has been shown to take not years but generations. Realizing this fact, the doctor must be prepared to adapt his role and medical practice to make possible the widest acceptance of western medical knowledge and technique. This article will deal with some of these problems, beginning with some of the general ones faced by western-trained doctors working in non-western cultures.

General Intercultural Problems

Many of these problems are due to the doctor's lack of knowledge of himself and the people with whom he is dealing. Self-knowledge is most important and the medical practitioner must realize that in moving from one culture to another he brings not only his technical knowledge and skills, but an enormous number of cultural ideas, beliefs, preferences, attitudes and opinions, all of which bear upon his work.[2]

At the root of many problems is ethnocentrism. This is the belief that one's own ways of thinking, acting and believing are the only right, proper and natural ones, with the consequent labelling of others' ways of behaving and thinking as "unenlightened".

Another naive misconception is the "common sense fallacy", where one presupposes a universal human nature leading to uniform responses in given situations. Failure to understand that human groups have worked out innumerable patterns of response to environmental stimuli can be a crucial shortcoming.

Many health workers are unable to differentiate between the essentials and non-essentials of medical practice, and equate scientific medicine with their own kind of social organization, represented in their minds by equipment seen in hospitals of large western medical centres. The "culture shock" of only a little black bag and one's own ingenuity is often disastrous.

Non-western medicine must be understood in relationship to a culture as a whole. Without this, the health worker is likely to embark on projects where success is impossible or results lead to unanticipated harm. Folk medicine is not necessarily a system of trickery practised by corrupt natives on unsuspecting victims. Folk medicine is an elaborate system of beliefs, practices and personnel training which a foreign medical practitioner cannot be expected to understand or use, but which has been proved valid in the eyes of the native by many successful cures. The native curer (called "shaman" in many cultures) is similar to the doctor in many respects. Both are trained for a great number of years and go through apprenticeship. Both have a code of ethics. Both take a history, that of the shaman often lasting days, and both do a physical examination. It is in the conception of causation that a difference arises. As a result of this the shaman has substituted "materia magica" for the "materia medica"

**'non-westerners' refer to those people whose cultures are not based on European and American science and technology.*

of the western doctor. The health worker should be aware that many of these folk cures have proven to have a scientific basis for their action.

Health practice must be seen as an integral part of the culture it serves. It is usually a reinforcing factor in the power structure of a community and any change will be felt throughout the culture, especially in the religious, political and domestic life of a people. It is these social agencies which are resistant to change affecting their power and position, and must be incorporated into any plans which the health worker has for a community if he is not to meet their opposition.

The broad consequences of health improvement often lead to other problems. Social change and acculturation, with their breaking down of traditional ideas and values create tension and conflict in people causing many problems in mental health. Population and food problems result from increased longevity and decreased infant mortality, and unless health workers are at the same time coping with these consequences, better health may paradoxically lead to future disaster.

Specific Problems and Ideas for Improvement of Intercultural Health Programmes

Illness and well-being are social as well as biological phenomena. What is called disease depends often on the cultural group involved. To the Yap, living on a small Pacific Island, worm infestation is no problem since worms are thought to be part of the necessary component of the digestive process. Normal behaviour to Dobuans is aggressive, paranoid and malevolent. Here the friendly active person is considered abnormal. Thus, in many cases, what we view as ill health is not viewed in the same way by the people concerned.

Western society is very time-oriented, looking always to the future. Non-western life may be geared to the seasons and other natural events, and oriented more to the present than the past. This often creates problems in the future-oriented preventive medicine programmes so readily accepted in out culture. Marie Vigil recognizes 'illness' only when there is pain or disability in the present. Misunderstanding with regard to time causes many missed appointments and misinterpreted instructions which could easily be avoided if health workers had knowledge of the natives' time orientation.

Doctors often fail to fully take into account the social nature of illness in non-western society. Western society stresses the private personal nature of the doctor-patient relationship. Native curing is usually done in the presence of the patient's family and sometimes with the entire community on hand. The family is an integral part of the pre-treatment consultation and of the treatment itself. Decisions regarding health are not individual but are usually family decisions. Such is the case among the Spanish Americans of the South Western United States where members of the family remain close to the patient to take charge of treatment. Western health methods and institutions do not recognize these traditional practices and thus are often an anathema to non-western people. Health personnel should learn first the relationship of the family to patient and doctor, and incorporate them into the decision-making and treatment as much as possible.

Western hospitals have shown themselves in many ways incompatible with many non-western concepts. Hospitalization is a traumatic experience for it means isolation from one's family, community and way of life. The native finds himself at the mercy of strange and often frightening forces. People's ideas of modesty may be totally overlooked, as in the case of the Navajo in New Mexico and Arizona in the matters of hospital attire and the private examination of women by doctors of the opposite sex. Food which is normally taboo is given to patients. Maternity hospitals are usually part of larger hospitals. Unfortunately, in areas like Burma and parts of Africa, the sight of or proximity to death is considered to be of great danger to a pregnant woman. The securing of specimens is frightening to many in places where any part of a person may be used in witchcraft against him. Hospital procedures which are essential for a patient's welfare should in many cases be adapted to suit the patient's expectations or they may not be used at all. Apparently the white brick hospital near Doctor Schweitzer's hospital in Dambarene found little acceptance or use among natives because of its impersonal rigidity, while Doctor Schweitzer's rather flexible programme attracted many natives. Here, a patient's family was an integral part of the treatment programme.

Resentment against doctors often has nothing to do with their medical practice. The doctor is considered to be an agent of the central government, an institution which finds little favour with rural natives. In places like Latin America and Egypt, governments have traditionally taken away lands and produce, and in Canada it was government surveys of the lands that confirmed unpopular boundaries and allocated crown land. It is a difficult task for the health worker to overcome this guilt-by-association.

Little can be done to solve a people's problem until people recognize it as their own. The people for whom health programmes are intended must be involved in the planning and implementation of any programmes. Support by local leaders has been essential to the success of any health programme. A leader who sets an example to his people in areas such as personal hygiene and immunization is often a great impetus. Many programmes to have latrines in a community only achieved acceptance after local leaders or wealthy families had them. Latrines were then thought to add elegance and status to one's household.

Practitioners of folk medicine have in many instances been incorporated successfully into health programmes.

New Mexico's State Department of Health had a midwife training programme among Spanish Americans. With minimum instruction, their technique improved greatly with the more difficult births being referred to local doctors.

In the minds of many natives there is a dichotomy in medicine between those ills to be dealt with by the curer and those to be dealt with by the western doctor. Many doctors have learned to work remarkably well with native curers, often finding them excellently equipped to deal with the psychosomatic complaints. In Nigeria, psychiatrists have learned to work well with native witch doctors to the benefit of their patients.

A novel and initially successful programme has begun in the Canadian North among Indian and Eskimo communities where native community health workers are trained. Natives with leadership qualities are designated by their communities and trained for about five months by the Department of Health. This training is very permissive and involves studying the worker's own community needs and then a central training programme. They work along side western health workers, adopting their message and interpreting the ideas of their people. They have proved to be a successful intercultural bridge and one of the frequent remarks by natives is, "Why weren't we told this long ago?" [3]

Health workers must always remain flexible in carrying out their health programme. Although the enemy is excessive rigidity, flexiblity to the extent that patient welfare suffers is obviously the other equally undesirable extreme.

The education of doctors has proved rather deficient in developing their understanding of other cultures and the role of medicine, as it is translated in those other cultures. Many schools pay lip-service to a background in the social sciences of anthropology and sociology but few really have shown a genuine recognition of its importance. Such studies would help give doctors a fuller comprehension of the people he is dealing with. A medical education, besides inculcating medical practices and scientific principles, should present a broad view of man.

> "Looking at man with the naked eye he is an individual. Studying man with microscopes, both visual and electronic, he is biological. Stepping back and viewing man through a telescope he becomes a small unit of society. All three perspectives are requisite for full comprehension."[4]

REFERENCES

1. Saunders, L.: Cultural Difference and Medical Care, p. 180, New York, 1954.
2. Saunders, L.: op. cit., p. 228.
3. Marten, E. G.: Culture and Communications—Training Indians and Eskimos as Public Health Workers, Canadian Journal of Public Health, Vol. 57, No. 11.
4. Stieglitz, E. J.: The Integration of Clinical and Social Medicine, in Social Medicine, I. Goldston (ed.), Commonwealth Fund, 1949, pp. 87-88.

SELECTED BIBLIOGRAPHY

1. Benedict, R.: Patterns of Culture, Mentor, 1960.
2. Foster, G. M.: Problems in Intercultural Health Programmes, Social Science Research Council, 1958.
3. Goldston, I.: Medicine and Anthropology, New York, 1959.
4. Mead, M.: Culture Patterns and Technical Change, United Nations, 1953.
5. Marten, E. G.: Culture and Communications—Training Indians and Eskimos as Community Health Workers, Canadian Journal of Public Health, Vol. 57, No. 11.
6. Polgar: Health and Human Behaviour: Areas of Interest Common to Social and Medical Sciences, Current Anthropology, Vol. 3, No. 2, April, 1962.
7. Saunders, L.: Culture Difference and Medical Care, New York, 1954.
8. Stieglitz, E. J.: The Integration of Clinical and Social Medicine in Social Medicine, I. Galdston (ed.), Commonwealth Fund, 1949.

Community Psychiatry

K. Chambers 6T9

The last decade has seen an accelerating interest at all levels of social organization in the problem of mental health. This movement had its beginning in 1909 with the founding of the National Committee for Mental Hygeine by Clifford Beers, a former psychiatric patient who was horrified by the conditions of treatment for the mentally ill.[1] Studies and recommendations of this organization and similar ones such as the Canadian National Committee for Mental Hygeine (1918) were largely ignored until after the second World War.[2]

The incidence of mental illness could no longer be overlooked. For example, a study at Johns Hopkins University (1935-55) showed that 11% of the population were recognized mental patients.[3] Furthermore the same study showed the incidence of mental illness as compared to that of other diseases. (Table I)

TABLE I Incidence of Psychiatric Illness as Compared to that of Other Diseases

Disease	*Prevalence Per 1000 Population*
Psychiatric	112
All Heart Diseases (including hypertension)	92
Arthritus	84
Diabetes	23

The breakdown of different psychiatric disorders for any population can be predicted on the basis of Passamanick's survey, 1957.[4] (Table II)

TABLE II Incidence of Different Psychiatric Disorders

Disorder	*Prevalence Per 100,000 Population*
Psychosis (1/3 schizophrenia)	430
Acute Brain Syndrome	14
Mental Retardation	1,500
Neurosis	5,270
Psychosomatic	3,650
Personality Disorder	1,500
Total	12,360
Severe or total disability (mostly psychotics and child retardates, 3% of neurotics, psychosomatics and personality disorders)	2,590

Studies can only enumerate the reported cases. The common "one out of ten" estimate seems at best to be an extremely conservative one. Such is the overwhelming problem facing today's psychiatrist. The existing means of treatment cannot be adequate if this overwhelming incidence of mental disease continues to exist.

To say that mental illness is merely an unavoidable complication of our culture is not enough. A concept of psychiatry, therefore must be created to deal with the need for more effective management. In formulating a plan, it is necessary to first review the existing facilities. These are briefly discussed below.[5]

1. MENTAL HOSPITALS

In Canada there are 107 in-patient hospitals which have more than 76,500 patients and a rated bed capacity of 64,519. The distribution is that shown in Table III.

TABLE III Distribution of Patients to Hospitals

Hospital Type	*Number in Canada*	*Total No. of Patients*	*Average Bed Capacity*
Mental or Psychiatric Hospitals—Federal, Provincial or Municipal	52	53,932	1,035
Private Mental or Psychiatric Hospitals	6	394	65
Hospital Schools for Mental Defectives	12	11,392	950
Institutions for the Aged and Senile	4	1,692	480
Hospitals for Epileptics	1	251	251
Psychiatric Units in General Hospitals (more unreported)	32	872	27
Total	107	78,533	
	c.f. Rated Capacity of 64,519 Beds		

These statistics speak for themselves of the abhorrent overcrowding of the public institutions. In this type of hospital, which should be no larger than 200-300 patients, there are 1,000-5,000 patients occupying buildings which often do not even meet the minimal health standards. The large hospitals are located in isolated areas and therefore cut the patient off completely from his home and family. Some patients have actually been kept in jail awaiting transportation to the hospital.

2. DAY AND NIGHT CARE HOSPITALS

These are increasingly important in the local community treatment of mental patients. There are, in Canada, 8 to 10 such hospitals with 10-30 daily patients. These figures do not include such services offered by many general hospitals.

3. BOARDING-OUT HOMES AND HALFWAY HOMES

These have a capacity for approximately 1,400 patients and present convalescent and rehabilitation programs for those patients without suitable home environments to return to upon discharge from hospital.

4. COMMUNITY MENTAL HEALTH CLINICS AND OUT-PATIENT DEPARTMENTS

There are 140 clinics which range from child guidance centres, to those for adult psychiatric patients, drug addicts, alcoholics and so forth. However, only two or three large Canadian cities have clinics with the full range of facilities available.

5. PSYCHIATRISTS

Only 600 of Canada's 18,000 physicians are qualified specialists and 400 of these are in part-time or full-time private practice.

6. OTHER COMMUNITY SERVICES

There are 32 social rehabilitation centres for post-care patients. Each of these serve approximately 1500 people at a time. Sheltered workshops and training centres are steadily increasing in number and quality. Social agencies such as the Children's Aid, counselling and recreational groups, and the clergy play a valuable role in early diagnosis, referral, and post-care rehabilitation.

7. EDUCATIONAL INSTITUTIONS

The classroom plays a role in primary and secondary prevention of mental illness in the child and adolescent. In the primary phase, teachers have a great influence, often underestimated, in the development of personality. Secondary prevention lies in the early recognition and referral for treatment. This requires a very close link between the school and the community clinics.

8. CORRECTIONAL SERVICES

Despite the fact that most criminals require psychiatric treatment, the psychiatric facilities of the jails and particularly the penitentiaries are very limited. Only courts in large centres have a working relationship with community psychiatric facilities. The problem is particularly acute in the juvenile courts. Juvenile delinquency has been shown to be directly involved in psychiatric disorders and can be classified into actual syndromes, as done by Jenkins.[6]

Thus, we have seen the overall available facilities for the mentally ill patient. Inadequate is the obvious word to describe them all. There are some particular aspects worthy of added discussion. Because public mental hospitals are not included in the Hospital Insurance Act (1957), their administration is directly under government control with little if any local autonomy. This presents many problems such as the administrative barrier between these hospitals and general hospitals. This Act also excludes mental patients from the insurance benefits received by all other medical patients. The legal formalities involved in admission to mental hospitals cause apprehension for the patient, family, and physician. The paucity of well trained personnel is common to all the facilities described. This may be attributed to low salaries, the geographic and social isolation of institutions, and the relative status as compared with other fields. In the para-medical and non-medical organizations, which are invaluable in early diagnosis and rehabilitation, the staff are poorly trained and unprepared for their role in the mental health program.

The present picture is that of a very fragmented scheme of treatment with very little emphasis on prevention. The search to improve mental health standards has led to a concept of an integrated program of all medical facilities and social agencies. The basic

premise is that of a shift from the overcrowded in-patient system to treatment services centred in the community. Such is the plan encompassed by community psychiatry. The findings of all the social sciences from anthropology to sociology consistently point out the vital interplay of man with his environment in his personal development. Thus the patient is not just the responsibility of the psychiatrist but of all of his environment, specfically the community.

The basic aim in the planning of a community mental health program is well stated by R. G. Norwick.

> "Our objective should be a total co-ordinated and integrated program for community services in which the hospitals, clinics, and social, educational, and correctional agencies are each regarded as an extension of, and at the same time, an integral part of the community."[7]

There are three general aspects involved in specific planning for community psychiatry. The first is the regionalization of psychiatric services. This requires the definition of what the community actually is. The concensus of opinion is that the basic unit must be a combined geographic, social, and demographic one in character. This is quite straight forward in the rural counties in which such a division already exists. However when one considers the large cities the boundaries are not nearly as clear cut. A community study of the new Metropolitan Toronto Borough of East York and Leaside (Yorklea) under the auspices of D. B. Coates of the Clarke Institute of Psychiatry will determine if the municipal divisions are satisfactory as "social psychiatry units."[8] Such regionalization for treatment is essential in Canada where local needs and characteristics of the population vary so greatly.

The second aspect of community mental health planning is the co-ordination and integration of all the phases included in psychiatric service: prevention, diagnosis, treatment, and rehabilitation. This requires a local administrative council representing all the organizations involved in the program. This "community mental health council" would be responsible for assessing and reviewing the present needs of the area and thereby instigating the changes required. Additionally, this group could prepare long-range plans for continuing improvement and development of the program.

The final aspect is the definition of each level of psychiatric treatment and the respective roles of the

TABLE IV Plan of Community Psychiatric Program[9]

Level I *Major Firing Line Professionals (dispersed in the community at large)*	Level II *Means for Social and Psychiatric Diagnosis and Brief Treatment*	Level III *Community Psychiatric Centres*	Level IV *Mental Hospitals (to be limited in size and number)*
		1. Consultation services to all levels (professionals and individuals)	
1. Non-psychiatric Physician in office or hospital practice	1. Psychiatrist in private practice 2. Community Psychiatric clinics 3. Psychiatric units in General Hospitals: a) out-patient units b) in-patient units	2. In-patient services a) Diagnosis and short-term treatment b) Special services	1. Long term treatment and custodial facilities for the severly disturbed chronic case
2. Public Health Nurses (working from community department of health), Other visiting nurses 3. Teacher (in the academic classroom)	4. Special guidance and health teachers and Public Health Nurses in the schools (may refer patients to the appropriate level)	3. Consultation services to out-patients followed in the homes by Public Health Nurses working from the Community Psychiatric Centre	
4. Policeman 5. Lawyer 6. Judge	5. Diagnostic services in the courts (may refer people to the appropriate level)	(NOTE: Clinics, hospitals, centres and agencies in Levels II, III, IV are maintained each by their own professionals: medical, psychiatric, para-medical under community jurisdiction)	
7. Minister	6. Social agencies: Vocational and psych-rehabilitation services (may receive patients from any level)		

(Modified after Daniels, R. S., 1966)

personnel. (Table IV). There are important points to be stressed in such a program. All phases of community treatment must be close to the patient's home. The whole aim is defeated if the patient must leave his local setting for therapy. Secondly, hospitalization should only occur when specific tests and treatment are required, when the environment is too stressful for the patient, or when the patient's disorder is a danger to himself or to others.

The implementation of an effective community psychiatric program will by no means by an easy task. There must be government legislation to give financial support before any effective measures can be taken. Patients must be covered by the insurance plans to alleviate the cost of treatment. Training of all personnel connected in any with the plan must begin immediately.

Despite the many problems facing mental health workers, the future of community psychiatry looks optimistic. Reports already show that relapses among patients treated in the community setting are fewer than comparable patients treated in the in-patient system.[10] However, the greatest reason for this optimism lies in the fervour felt by all those working in community psychiatry. As Sloane stated simply in the conclusion of his article "Problems of Community Psychiatry", "The task set is an exciting and challenging one". T. S. Eliot has unknowingly expressed the 'task set" in a selection from the "Choruses from 'The Rock' ".

"Much to cast down, much to build, much to restore;
Let the work not delay, time and the arm not waste.
Let the clay be dug from the pit, let the saw cut the stone,
Let the fire not be quenched in the forge."

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REFERENCES

1. Foucault, Michael: L'Histoire de la Folie et L'Age Classique: Paris: Plon: 1961.
2. Canadian Mental Health Associaion: More for the Mind: A Study of Psychiatric Services in Canada: 1963.
3. Johns Hopkins Committee on Chronic Illness in the Large City: Vol. 4, Cambridge, Mass.: Harvard University Press: 1957.
4. Passamanick, B., et al.: Survey of Mental Disease in Urban Population: 1957.
5. Mental Health Statistics 1955-1961: Dominion Bureau of Statistics: Ottawa: Queen's Printer: 1961.
6. Richter, J. et al.: Psychiatric Aspects of Crime in Aspects of Psychiatric Research, Osgord, 1962.
7. Norvick, R. G.: A dynamic component of Community Mental Health Practice, American Journal of Orthopsychiatry, Vol. 26, October 1956.
8. Coates, D. B.: Submission for Community Study Project (Yorklea Project) Clarke Institute of Psychiatry, 1966.
9. Daniels, R. S.: Community Psychiatry, Community Mental Health Journal, Vol. 2, No. 1, Spring, 1966.
10. Ewalt, J. R.: The Community Stake in the Mental Health Program, American Journal of Psychiatry, Vol. 112, October, 1955.

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Biological And Physical Self-Regulatory Systems

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INTRODUCTION

During the past two decades there has been increasing recognition of the importance of interaction between the disciplines. For example, the interfaces between medicine and engineering, manifestations of which are artificial organs, ultra-sensitive instrumentation, computer utilization in the analysis of data, the study of complex systems, etc. have been particularly rewarding. In particular, the concept of the physical and mathematical model has proved to be powerful in scientific disciplines, and it has been particularly valuable in the study of control systems of all kinds. Furthermore, it is not coincidental that some of the earliest applications of the computer as a simulator (i.e. model) were in connection with studies of the controllability of chemical processes and of certain man-machine control systems such as, for example, aircraft control.

In this paper the term "self-regulatory" is used to describe a system, or process, capable of adjusting its behaviour as dictated by changes in the external environment. There is in fact a hierarchy of self-regulating processes inherent in all biological, sociological, economic, chemical, etc. systems. This comprises protective controls, automatic regulating systems (such as the simple thermostatic controller), and adaptive controls which at all times attempt to optimize the behaviour of a system in spite of essentially unpredictable environmental changes. By far the most complex self-regulating process known to man is man himself. The hierarchy of automatic regulating systems, comprising a fantastically complex coordinated network of neurons, nerve fibres, muscles and glands is far beyond our comprehension. It is not only the control of single variables, such as blood temperature, which is complex but the fact that there is a vast multiplicity of regulatory processes which interact one with the other under the central control of the brain. It must be stressed, therefore, that physical models of complex biological self-regulating processes must be regarded as very crude models. But, on the other hand, such models stimulate dialogue between medical scientists and engineers and their importance is increasing.

Self-regulatory systems are error-actuated insofar as, through information feedback channels, the actual behaviour of the system is compared with that desired (e.g. the goal) and the corrective action depends solely on the difference between desired and actual behaviour. In the majority of man-made physical and chemical self-regulatory systems, we refer to "desired levels" i.e. desired liquid level, or temperature level, or pressure level, etc. In order to optimize, for example, the behaviour of a system, when the environment is non-static, it may be necessary from time to time to change the desired levels. Furthermore, the relationship that exists between the desired levels and the ultimate "goal" of the system (perhaps the "yield" of a chemical process) is often complex and, increasingly, modern computers are being used "on-line" in its determination. In the cases of most biological self-regulating systems, however, because of the complexity of the interactions between a vast multiplicity of variables, the correlation between variable levels and goals is impracticable. Indeed, complete specification of the goals themselves, except in very specialized systems, is not possible.

The cybernetic sciences which embrace the theory of self-regulating systems, have played a significant role in pointing out the fundamental similarities between biological and physical communication and control processes. And in spite of the massive gap in complexity between biological and physical control systems, it is noteworthy that cybernetics, and cybernetic models, are opening up important areas of research in the biological sciences and are giving rise to an increased understanding of the basic mechanisms incorporated in self-regulatory processes. In such research the computer is playing an indispensible role.

MODELS

The importance of models in scientific research has already been mentioned. In the physical and biological sciences, for instance, models may be regarded as hypotheses which provide the starting point for specific scientific researches. The Bohr model of the atom gave physical scientists considerable insight into atomic structure while, more recently, the model of the structure of the DNA molecule has shed considerable light on the life process.

Models have proved especially valuable in the study of self-regulating systems essentially because of their

flexibility. This implies that a wide range of values of key control parameters can be studied using an appropriate model, and the approximate behaviour of the actual system under study for a range of conditions, can be predicted. Another important attribute of the model arises due to the fact that most models have universal applicability. For instance, the basic structure of self-regulatory processes, whether they be biological, physical, economic, etc., are equivalent and hence the corresponding models are also equivalent.

The model-building process itself can be regarded as a regulatory process in the sense that the behaviour of the model is compared with the actual or desired behaviour of the real-life system and changes are made, in order to achieve an adequate degree of realism, by comparing system and model behaviour respectively. It should be stressed, moreover, that the model-building process is of extreme importance in scientific research. The questions which arise in the model building process frequently throw new light on biological and physical phenomena.

Most self-regulatory systems can be classified as *stochastic* processes. This means that system behaviour is probabilistic in character and is only specifiable in terms of statistical laws. The natural environment is essentially stochastic—it is impossible to predict the future except perhaps in probabilistic terms. Indeed, if precise predictability were possible, the process of self-regulation would be trivial, and it can be argued that life itself in a completely deterministic environment would be impossible.

The modelling of stochastic self-regulatory processes has been handled successfully for limited numbers of control variables using digital and analogue computers. For example, the behaviour of an environment, defined as a stochastic system, can be simulated by the so-called Monte Carlo process, which as the name implies, depends on the generation of random numbers by the computer. It is probable that these techniques will find increasing applicability in the study of the essentially probabilistic regulatory processes encountered in biology.

Models of regulatory systems which incorporate the property of self-adaptation (i.e. systems which adapt their behaviour to a dynamic environment) suggest that such systems must incorporate certain basic characteristics. These are, first, the ability to store data; second, the ability to recognize and develop spatial and temporal patterns in the stored data; third, the ability to establish cause-effect relationships, usually by invoking the feed-back principle; fourth, the ability to carry out experiments, in the sense of "probing the environment", and to fit the results of the experiments into the behavioural patterns mentioned above; and fifth, the ability to time events. The processes of data storage, for example, in the central nervous system, and of timing events, e.g. biological clocks, are assumed to be obvious requirements in the regulation of processes. The remaining three requirements are discussed below.

FEEDBACK

The feedback process is one of the fundamental life processes in the sense that life would not be possible without it. Feedback is usually used as an abbreviation for "information feedback"—it normally implies the continual monitoring of the behaviour of a system. Its practical significance increases as the degree of uncertainty in the operation of a system increases. If, for example, a regulating process is completely predictable (this rarely happens) the degree of uncertainty is negligible and information feedback is not necessary. On the other hand, if it is impossible to predict future behaviour. because of the uncertainty of the environment, feedback information is essential if control is to be achieved. Clearly feedback is universal and can be regarded as the "universal monitor" of all behaviour.

It is impossible to estimate the incredibly large number of information feedback systems involved in the human body. It would be surprising if these were not measured in terms of billions because the majority operate at cell level. And these control systems form a tremendously complex network of self-regulatory processes. The conditioned reflexes are typical examples of such processes,* and the process of controlling metabolism, involving as it does complex biochemical feedback processes, is central in animal homeostasis. In the latter, although the thyroid gland directly regulates the metabolism of the body its behaviour is in turn regulated by thyroid stimulating hormones which are produced by the pituitary gland. And the pituitary gland is stimulated by neuro-humoral secretions produced in hypothalamal neurons and regulated by sectors of the nervous system which are stimulated by both the internal and external environment.

The learning process itself, when reduced to its fundamentals, is essentially a goal-seeking process in which information feedback is inherent. During the learning of a specific task, for example, the level of attainment is monitored continuously and compared with the desired level of attainment (the goal)—the process can be described in terms of "trial and error" behaviour. This process is fundamental in the process of evolution. And evolution epitomizes self-adaptation and regulation in which a multiplicity of reflex arcs and consciously stimulated regulatory processes play a basic role. But learning, in man or in machine, involves, in addition to information feedback controls, phenomena which involve the storage of information and its retrieval, and, of supreme importance, the

**The so-called reflex arc comprising sensory nerves, spinal chord neurons, spinal motor neurons, and muscles comprises a feedback control system.*

property of pattern development and recognition in which memory is structured through associations of events in space and time. It has been suggested that memory recall is dependent on the specific reorganization of neuronal associations and that the activity of perhaps millions of neurons is involved in recalling a single event. This brings us to the pattern recognition requirement in all self-adapting systems.

PATTERN RECOGNITION

In order to be self-adaptive a biological or physical system must incorporate a capability of storing information relating to the past behaviour of the system. The more patterned this is, the more predictable the system and its environment and hence the more readily adaptable. However, when the environment is non-stationary in the sense of being predictable only to a low degree, the stored patterns must be continually up-dated and continual efforts made to determine basic structures. In the control of chemical processes these structures are developed in terms of auto-correlations in time of single variables and cross-correlations in space between various variables. And the patterns we establish are essentially probabilistic patterns because certainty is unknown, especially in the biological world.

The patterns we deal with in self-regulatory processes can also be regarded as "associative patterns". A comparatively simple example arises in the Pavlov experiments in which a dog learns to associate the ringing of a bell with the imminent arrival of food. In the dog's brain an "associative pattern" is established which is predicated on the conditional probability of food following bell-ringing. This is the sort of associative pattern which arises in self-regulatory processes. When high probability patterns are developed there is a high degree of predictability.

In physical self-regulatory processes such as, for example, the on-line computer control of a chemical process, the associative patterns are developed by the computer and stored in the computer's storage system. The patterns are essentially simple and usually involve no more than five or six interacting control variables. Furthermore, in spite of the ultra-high speed operation of modern computers, development of the pattern is normally a slow process because the control data are generally difficult to dissociate from a mass of superfluous or redundant information which is usually described as "noise". On the other hand, the human brain has a fantastic capability for pattern recognition—and this includes not only physical patterns and probabilistic patterns of varying degrees of complexity but also highly abstract patterns and imagery which baffle the most fertile imagination. And the pattern is continually changing. Sherrington, in poetic language, described it as "The enchanted loom (i.e. the brain) weaves a dissolving pattern, always a meaningful pattern, though never an abiding one; a shifting harmony of sub-patterns". The fantastic complexities of neuronal activity in establishing spatio-temporal patterns of such complexity provides reassuring evidence that even though computers are developed continuously for a thousand years, they will not compete with the brain in this regard.

PROBING THE ENVIRONMENT

Unless, as was pointed out previously, the patterns in a self-adaptive system are continually updated the maintenance of stable control may be impossible. The possibility of unstable (i.e. oscillatory) behaviour in all control systems is enhanced by time delays in the control loops and to counteract their influence predictive patterns must be developed. Further, if the external environment is subject to uncontrollable disturbances (e.g. the process may be sensitive to weather conditions) it is necessary, in order to maintain a capability of adequate prediction, to probe the environment continually.

The process of "probing the environment" can be likened to the process of experimentation in research. But it is also important to note the equivalence, in principle, between the trial-and-error process of natural selection and the process of self-adaptation. In the former the "environment is probed" through genetic changes, either mutations or genetic transfers, which occur in cells which thereby establish new interactions between the biological system and its environment. While in the physical, or chemical, self-adaptive system the environment is probed by modifying the "desired" levels of key variables and observing the over-all effect on the behaviour of the process. Assuming a dynamic environment, involving a high degree of randomness, it is important that the environmental probes should be random. Otherwise there is the possibility of the regulated system behaving in a predictable manner and in such circumstances adaptation to a non-stationary environment would be impossible. The extent to which this argument applies to complex biological systems is, of course, problemmatical. It would imply that biological "learning processes" are predicated on random mutations, and that the mechanism of the trial-and-error process of natural selection is also that of the learning and self-regulatory processes at all levels in the system.

The probes, or experiments, provide continuously, or, in the case of sampled or discrete systems discontinuously (mutations are by definition discontinuous in time), are used to update the behavioural patterns which relate the behaviour of the regulated system, or process, to its environment. The probes are as essential in the self-regulatory process as feedback—indeed the two mechanisms are essentially complementary insofar as the result of a probe or experiment is fed back to a "computer" or "data-processor" or "pattern develop-

ment" system, which provides the degree of predictivity essential for the adapative process.

A useful analogy is to consider the process of climbing a "non-stationary" hill when blindfolded. In order to test whether or not one is at the top of the hill it is necessary to explore the hill continually and to react to changes in the hill configuration. In optimizing chemical processes the hypothetical hill is n-dimensional and the "yield" of the process is equivalent to the "altitude" achieved at a particular time.

SUMMARY

We have developed a simple "model" of the process of self-regulation when a system, biological or physical, is subjected to an uncertain environment. The process involves the storage and patterning of information, the establishment of cause-effect relationships through feedback processes, and the carrying out of experiments which effectively probe the environment and provide information to update continually the behavioural patterns of the system.

The self-adaptive model discussed in the paper applies also to the adaptation of a society to its environment. The storage of information and the patterning of information are analogous to history and tradition. Probing the environment corresponds to carrying out economic, sociological and technological experiments, the assessment of the results of which changes the patterns upon which society evolves—for example, new behavioural patterns are derived by correlating new knowledge with old knowledge. In this way sociological evolution is maintained.

REFERENCES

1. Bush, R. R. and Estes, W. K. (Ed.): "Studies in mathematical learning theory", Stanford Univ. Press, 1959.
2. Hardy, J. D.: "Physiology of temperature regulation", Physiological Review, 41, (1961), 521.
3. Stark, L.: "Stability oscillations and noise in the human pupil servomechanism", Proc. IRE, Vol. 47, Nov. 1958.
4. Stanten, S. F. and Stark, L.: "A statistical analysis of pupil noise", Trans. Bio-medical Eng., Vol. BME-13, No. 3, July 1966.
5. Warner, H. R. and Cox, A.: "A mathematical model of heart rate control by sympathetic and vagus efferent information", Journ. App. Physiol., 17 (1962), 3.
6. Wiener, Norbert: "Cybernetics", John Wiley & Sons, 1948.

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Directions In Medical Engineering

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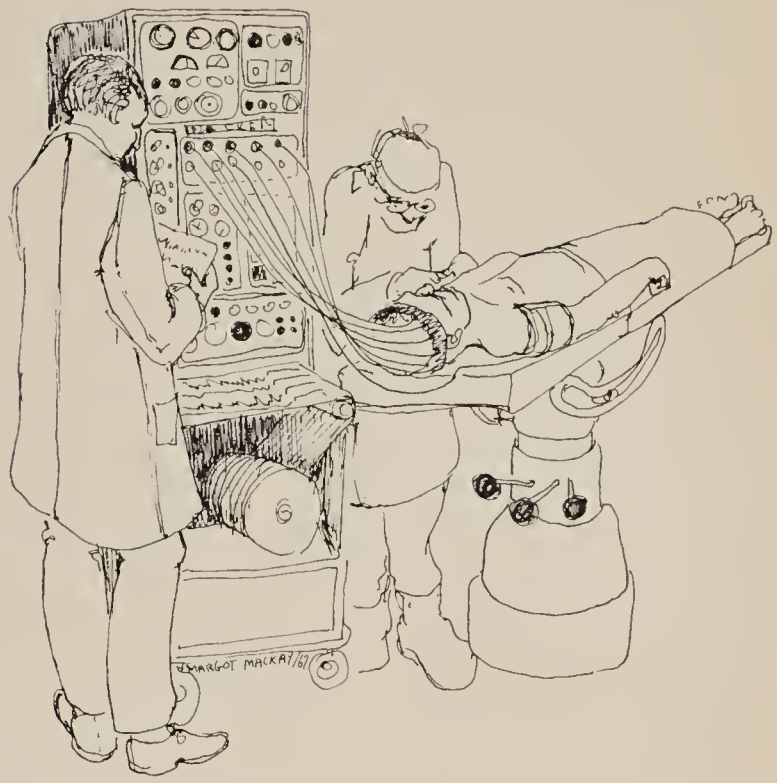
The views expressed in the following article represent only the ill-considered opinions of the author, and he does not recommend their introduction into serious clinical discussions—at least not with some clinicians he knows. E.Ll-T.

Man faces a universe which is either indifferent to him or is actively hostile. He has survived and flourished (up until now) because he has used his physical and mental talents to deal with the challenges around him, demonstrating his enthusiastic, though intuitive, acceptance of the theory of creative evolution.

Engineering is the profession through which he strives to control his external environment, and Medicine the profession through which he strives to control his internal environment. Both have advanced rapidly since they concentrated on applying science and shed such impediments as philosophy, religion and humanism.* This has taken them on a collision course and at present their indeterminate impact surfaces are fusing to produce an active offspring known as Medical Engineering (along with some questionable metaphors). There is hardly a specialty which has not been affected by the instruments, techniques and concepts which the engineering specialties have produced. Worse still, medical and engineering specialists are going off together to breed second order specialists—offspring who are incomprehensible in two languages.

A lot of this intercourse is hidden from public view because most people's mental picture of the modern engineer is no more accurate than a picture of the modern physician as an elderly gentleman dispensing understanding and placebos (wrong on three counts). They formed their image at college where the engineering undergraduate is about as good a prototype of the engineer as the medical undergraduate is of the physician. These inhibited students are enjoying—alas without realization—their last experiences of freedom before the constricting armour of professional responsibility is riveted on.



For Medicine and Engineering are the two major scientific professions whose primary responsibility is to apply science to the service of man. When the cynic points to blatant examples where this concern is ignored he is, in fact, pointing to examples of bad engineering or bad medicine. If you spend your life treating the diseases of self indulgence in idle people, or in designing electronic circuitry to display a glorious colour, the virtues of some deodorant, then you are liable to sneer at 'professional responsibility'. But when you watch a man struggling to exchange-transfuse your new-born child, or feel your aircraft flexing as it climbs through storm gusts, you are likely to remember it with gratitude.

Most engineers are somewhat startled to hear that they are members of a man-centered profession, but this is clear in one of the oldest difinitions of engineering made by the Institute of Civil Engineers in 1829. 'Engineering in the art of directing the great sources of power in nature ot the use and convenience of man.' Everything the engineer does is designed to ultimately affect man in some way. He may build machines to serve him, or weapons system to destroy him. Products like some automobiles reflect a certain ambiguity of purpose.

Both engineering and medicine are also action-professions whose objective is to do things and make things. The modern engineer is a creator who applies science, empirical knowledge and art to change and control

**This is not their fault. A mechanical engineer (Wittgenstein) has led the philosophers safely away into linguistic analysis, assorted self-destructive theologians have removed God and their own profession from the scene and the world's leaders have demonstrated the basic beastliness of man. This has left our professions with only their naive philosophy of service to others, and an admiration of a God who, whatever he may lack in existence, certainly knows his job when it comes to biological mechanisms and engineering design.*

man's surroundings, in much the same way that the physician applies science, empirical knowledge and art to control what goes on within man.

Engineers and physicians also function as scientists upon occasion, and seek new knowledge for its own sake, but even in research their primary aim is knowledge they can apply. And the two professions have made so many basic discoveries that it is enough if they show a respectful diffidence in the presence of the Scientists—they need not grovel.

This difference between a science and a profession is of more than academic importance. The professional man, even when he is functioning as a scientist, has responsibilities and constraints which the true scientist does not have. For example, the clinical pharmacologist can get into serious trouble if he lets his scientific interests outweigh his professional responsibility when dealing with patients. The aerodynamicist's final responsibility is still to the man who will fly the aircraft.

Another important difference, not always fully realized, is that the professional functions in real time. He has to make decisions and take actions in the face of changing situations and a future he can only predict in probabilistic terms. He is always trying to change the future through his skills. The scientist on the other hand, is usually not bound to real time. He can repeat experiments, and is horrified at a sacrilege such as looking at the results as they emerge and using them to change the conditions of an experiment while it is in progress. His responsibility is to find things out about Nature for their own sake, but not to change what he is investigating. The professional man on the other hand is trying to control Nature—or at least enjoy a minor seduction.

The reason why both professions have made such tremendous advances in the last few years is through their increasing ability to understand and apply scientific knowledge. It is this ability which is bringing engineering and medicine into closer contact.

As I am writing for physicians and protophysicians, I had better indicate what I mean by 'modern engineering'. Intuition, experience and an act of creative thought are as essential to great engineering today as they have ever been. But I think that modern engineering shows three additional characteristics, all of interest to medicine. These are the use of advanced mathematics as a major tool, the use of accurate measurements and scientific method whenever possible, and the use of the systems approach. Great engineering can be achieved without any of them, just as it is still possible to be a great clinician in certain fields with the minimum of science, but it is becoming harder and harder.

The use of the system approach (and some engineers would disagree with me when I call this a characteristic of a modern engineer) is particularly appropriate, because it means that an engineer is not concerned with only one element in the complex systems he is designing and building, he is concerned to some extent with all the elements and also with the interactions between them. For example, he must include the physiological and psychological characteristics of the pilot in his design of an aircraft. Every engineered system contains human beings somewhere, even if only as the ultimate user of a product. The modern engineer must always consider these man/machine interfaces, and this is equivalent to the often-repeated and often-ignored medical dictum that we should treat the whole patient, and not just her left breast.

The extent of the interactions between engineering and medicine surprises most physicians — and most engineers. These interactions are conveniently grouped under the following seven headings.

1) Instrumentation

The design and development of an instrument is essentially engineering, although the man who does it may not be an engineer. For many years engineers have been providing instruments for use by physicians, developed either from their own discoveries or those of colleagues in the basic sciences. The design and construction of good instruments and the conversion of research techniques into useful clinical tools will remain one of the most important services that the engineer can render medicine. The tendency to decry instruments as 'gadgets' is most unfortunate, and reflects the same snobbery which refers to a 'scientific success' as the rocket ascends, and an 'engineering failure' when it explodes. The invention and construction of the first opthalmoscope by Helmholtz opened up a completely new area of clinical medicine, as did the development of the practical EKG by Einthoven and the EEG by Berger. The results which have come from a new instrument have often been so exciting that they have overshadowed the genius of the initial invention. I sometimes think of the ex-medical student Galileo showing his telescope to academic colleagues and hearing them mutter the medieval Latin equivalent of 'gadget' into their beards.

The number and complexity of the new instruments starting to flood into clinical medicine can both awe and frighten the physician, whose background has seldom included much training in instrumental methods of measurement. It should not be necessary to repeat that an instrument is basically an extension of the physicians own senses, and that he must process the information coming from it, evaluate it and use it to help him reach clinical decisions, or to carry out procedures he cannot otherwise do. He may have to use computers and so on to help him with this, extending his intellectual capabilities through such mental tools in the same way that other instruments extend his sensory and neuro-muscular capabilities.

Unfortunately, we all tend to use the mechanisms of rejection towards things which arouse our anxiety be-

cause we do not understand them or because we feel they threaten us in some way. When faced with the plethora of data which new instruments and techniques pour out, I suggest we remember that ideally we need all the information we can get about a patient. Rejection out of hand, the 'don't confuse me with any more facts' attitude is not a professional reaction. Our common inability to integrate all the data we may receive should encourage us to find better methods of data processing rather then look the other way.

Moreover, in order to use the information coming from a medical instrument, we must understand its limitations and capabilities. This demands that we learn more about the science of measurement, and expand our knowledge of mathematics physics and statistics.

2) Methods and Techniques

An instrument is a piece of hardware designed to do a certain job. Engineering methods and techniques represent something more abstract, ideas which may be applied directly or may be embodied physically. A large number of sophisticated techniques were developed to deal with practical engineering problems, and their medical importance was later realized. For example, electronic amplifiers were developed for radio and telephone circuits, but made the EEG and the modern EKG possible. Computers were developed to help solve engineering design problems, especially those connected with artillery, and from this beginning, they have spread into almost every activity of our modern civilization including medicine.

One group of techniques is of considerable future interest, those included under 'Operations Research' now a branch of Industrial Engineering. These are methods such as Programme Evaluation and Review Technique (PERT), Critical Path Planning, Queueing Theory, Dynamic Programming and others. They reflect the point referred to above that the professional, both engineer and physician, has to function in real time and design and control increasingly complex procedures which demand fast accurate decision making, such as the control of the flight of a space vehicle or of the surgical procedures involved in an organ transplant.

3) Replacement and Repair

The provision of cosmetic or utilitarian prostheses is a service which the engineering craftsman has rendered medicine since the stone age. The development of control system theory and of new materials has made the active artificial organ feasible. We are developing controllable artificial limbs, and we have rather primitive artificial kidneys and hearts. It appears likely that, by the end of the century, we shall be able to carry out short term replacement of every vital body organ except for the central nervous system and the organs of special sense. At present in North America, there are some 25,000 artificial heart valves and some 12,000 artificial pacemakers operating inside people so this is already a very active area.

The present obstacles are the limited ability of engineered organs to maintain and repair themselves, the characteristics of available materials, and the lack of any engineered power source which can approach the effectiveness of muscle at body temperatures. The Creator is, among other things, a superb engineer. There is no material that can replace bone or a function for function and strength for strength basis. It looks as though we will be able to physically lick any general purpose robot for a long time to come. However, the phylum 'Chordata' is more than three hundred million years old, the phylum 'Automata' is less than thirty.

4) Life Support Systems

It is not particularly attractive to contemplate the idea of a human being consisting entirely of engineered parts except for his brain and his eyes. The development of true life support systems seems a much better solution. These are engineered systems to support a human being through periods of intolerable environmental stress, whether that stress comes from outside him as in space or the deep ocean, or from inside him in the form of disease. Some of the oldest examples are the iron lung and the infant incubator. A more modern example is the heart-lung pump, and the external auxillary ventricle.

The effective life support system should be able to sense the physiological needs of the person it is supporting and provide him with what he requires. The ideal life support system should be able to take over all his vital functions, relieving diseased organs of their load and giving the 'vis medicatrix naturae' or medical therapy time to work. There should be a true symbiosis between the engineered and the living system, so that each can sense the status of the other and assist when necessary. The present infant incubators are starting to acquire this capability, through the development of suitable transducers and the application of control system theory. We can postulate, in the far future, the artificial uterus and the possibility of 'suspended animation'. Whether we want them or not is quite another thing.

5) Materials Science

The living body is a challenge to the developer of new materials, for it is a far more hostile environment than outer space. The body has spent millions of years in learning how to attack, destroy or neutralize foreign object within it. Sometimes its attempts are disastrous to itself; it had no opportunity of learning about radioactive fall-out or the products of incomplete combustion in the primitive world in which it evolved.

The triumphs of the organic chemist and the metallurgist in the last twenty years have given us a number of materials which have been of use in almost every branch of medicine, and have allowed us to build things like artificial heart valves, blood bessels and the membranes for artificial kidneys and lungs. One area of great potential importance is the development of satisfactory surgical adhesives. Then perhaps we may be able to avoid further traumatizing our patients by plunging sewing needles into them and intermittently securing the edges of their wounds with animal intestines or the secretion of the silk worm.

A number of techniques have also been developed in Materials Science during the last few years which are of potential value in medical research but which have hardly been applied as yet.

6) Environmental Engineering

This is probably the oldest area of interaction between engineering and medicine. Hippodamus of Miletus, a physician, who held that among the causes of disease was the shutting out of light and air by narrow winding city streets, acquired such fame as a town planner that Pericles called him to Athens to lay out the new port city of Piraeus. He used a checker board design centered on a central place of assembly, the agora, and established a pattern followed ever since.

We often think the great victories of public health were won with the removal of the major plagues from the civilized world. We are only now becoming aware of pollutions which are less dramatic than Vibrio cholerae—but perhaps as potentially deadly. Public health will always remain one of the most important joint efforts of engineering and medicine, if only because its failures can lead to such disaster. It is exciting to think of artificial hearts, but the failure of such a heart will only kill one patient, the failure of a public health engineering system may kill by the thousands or even millions.

Moreover, there are more subtle possibilities of damage arising in our modern engineered environment through the powerful rapidly acting machines and systems we are developing. One is the effect of bad design on the people using the systems. Consider, for example, the effect on your catecholamine levels and your cardiovascular system when you are driving at sixty miles an hour on a wet night and switch off the headlights when you intended to stop the wipers, through selecting the wrong knob from the line of exactly similar knobs on your car dashboard. There is a good deal of medical opinion to support the view that such repeated small physiological stresses can add up to permanent physiological and psychological damage. For all we know, the psychological stressors from the unnecessary ugliness and alienation produced by some of our engineered systems may be even more damaging to soma or psyche.

There are more dramatic failures also. The surgical and medical problems involved in treating people who have been burned above the waist, frozen below the waist, have multiple fractures and are covered with a mixture of water and fuel oil may be fascinating. But the etiology of their condition may lie in the design of an instrument which did not suit the physiological or perceptual characteristics of a pilot or air traffic controller. The physician is the only professional in the applied life sciences who by his training and experience can hope to be familiar with all aspects of man in health and disease. He should therefore join with physiologists, psychologists and human factors engineers in tackling the gigantic problems of the acute and chronic stresses which are acting on man from his engineered environment. Such an idea is foreign to the thinking of most physicians, perhaps because this is one team where the physician may not head the pecking order. The only specialty which has really faced this responsibility is Aerospace Medicine, which deals principally with men in excellent health and directs much of its attention to helping them function better in tasks which are always difficult and sometimes dangerous, but are nevertheless among the few tasks in the modern world which allow men to reach their full physical and mental capabilities.

What I am saying is that industrial disease is more than the diseases peculiar to factories and mines. It includes the diseases arising from the products of those factories. Yet, outside Aerospace Medicine, I have never met an industrial physician who took any great interest in what his factory was making. And I have met industrial psychologists and human factors engineers who had tried to interest their plant physicians in some of the fascinating problems involved. As a parallel to this most Naval physicians with whom I have served seemed more interested in pediatrics or obstetrics than in underwater physiology and diving medicine.

7) Engineering Concepts in Medicine

A concept is a thinking tool which immensely increases our intellectual span. Engineering concepts are concepts which have arisen through men's attempts to make and do things, their attempts to control nature. From these attempts a number of generalized concepts such as cybernetics, systems theory, information and communication theory, and mathematical modelling have arisen.

Since the nineteen-forties something quite new has appeared in our part of the universe, systems with the ability to adapt their behaviours to reach a desired goal, to sense their environments, to make probability decisions, to recognize primitive patterns. These were first exemplified by the self directed gun radar combinations and have been followed by the automated optimizing chemical plant and the hunter-killer missile. These are systems which are purposive and yet non-living. Before

they arrived purpose and its related attribute were the prerogative of living things.

Teleological questions are meaningless to the physical scientists, for all purposive systems in nature are alive. The study of goal-seeking non-living entities lies within the field of engineering and part of what is being found about their behaviour is likely to be of future use in dealing with the disorders of man, the most effective and most complex purposive system of them all.

CONCLUSION

The day is gone when we could climb a pole planted firmly in the center of some field of clinical or scientific specialization, to sit on a platform at the top, isolated securely from all except the fellow specialists who shared our platform. Candidates for Fellowships and Ph.D.'s come swarming up after us, and although we still lean over and knock off about half of them with an obscure question in the orals, some of them are starting to swipe back with things we have never even heard of, or worse still, are starting to ignore us and put up their own poles in our field.

Annoying people like statisticians have started to come along to shout derisive comments up to us. Sometimes they use unfair tools, like computers, to examine our therapeutic results, roar with laughter, and come and shake our poles. ("Do you know the only statistically significant difference between atropine and propantheline?—One costs a cent and the other a dime", or "Have you seen the analysis of variance between patients with five years of psychoanalysis and their matched controls?—A significant improvement in the untreated".)

They set up infuriating instruments like automatic analysers which insist on telling us lots of irrelevant things about the biochemistry of our patients—when all we asked for were the hemoglobins. And they do it so fast that we have no time for decent contemplation while we form our clinical judgments.

Crab-grass-like intruders keep on growing over the fence around our field, seeding it with weeds from some remote patch. We can find a gloomy satisfaction in knowing that we are not the only ones invaded. In the distance, we can see archeologists struggling with the mysteries of nuclear physics because they have been invaded by radioactive carbon dating, and astronomers trying to cope with electronics because the radio spectrum has started to flourish with the visual.

Only the mathematicians sit happily playing games with pencils and paper. And even they are being disturbed by people who wander over to tempt them with goodies like computers, numerical methods or interesting observations from the real world, enticing some of the weaker brethren away from the pursuit of Truth —or their own private amusements.

All this confusion reflects the unfortunate fact that Nature does not allow herself to be dissected along sharp tidy lines, and the attempts of the Universities to pretend that her anatomy can be represented like a housewife's guide to the best cuts are becoming quite frantic. The Natural Designer has a vast scope and ignores the boundaries of the academic and clinical disciplines. He uses the best available mechanism, whether it be electrical, biochemical, physical, mechanical or God knows what else to achieve his aims—and he mixes these mechanisms intimately. In the eye, for example, he has used optical lens systems, the effects of quantum physics, photochemistry, electrochemistry and biochemistry, dielectric waveguides, information processing systems, stochastic processes, conditional probability analysers, frequency modulation, pulse time modulation, pulse width modulation, continuous servos, intermittent servos, bandwidth expansion, bandwidth contraction, decision making systems—and a lot of other mechanisms we have not tumbled to yet. All this before the signal even gets away from the retina. The difficult part of the visual system, up along the optic nerve, is still to come. Will the real expert on the eye—clinical or experimental—please stand up?

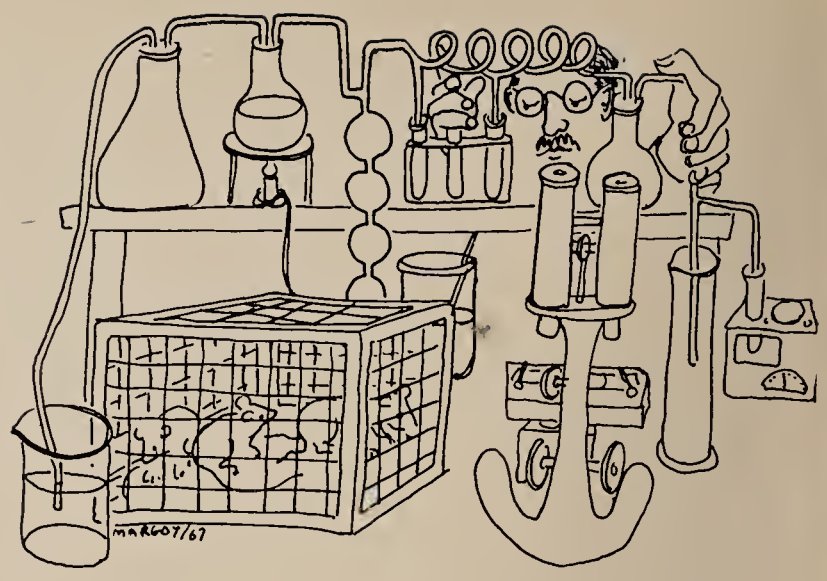
Most of us have to specialise today because there is so much to learn in even the most limited area. But limited knowledge, however deep, is no longer enough. We have to generalize as well, because there is hardly an active medical or engineering field where we do not have to communicate with a lot of other specialists —some from the craziest places. We are forced to try and translate their hideous jargon, and make them understand our scientific language.

And we are unlikely to communicate very well with anyone who thinks his field is as important as our own (absurd delusion) unless we disguise our natural superiority and climb down to talk to him. He will refuse to stand at the bottom and shout up.

Good luck, and in the words of the old engineering motto, 'Nil illigitimes carborundi'.

The Future Of The Clinical Laboratory

S. M. MacLeod 6T7



INTRODUCTION

The last one hundred years have been exciting years of innovation in all the varied fields of medicine but nowhere have changes been more radical and more promising than in the clinical laboratory. Modern physicians accept as commonplace a wide range of esoteric determinations readily available in the laboratories of teaching hospitals. To-day this field is of particular interest because we are on the threshold of a new era wherein sophisticated computers and auto-analyzers may permit us to monitor an incredible range of biological parameters on all hospital patients or even on our healthy citizens. It is the purpose of this brief discussion to outline the possible future of clinical laboratories as seen against the background of their existing situation.

EXISTING PROBLEMS

In earlier hospital laboratories sevices were often rendered by residents or other personnel virtually untrained in clinical chemistry. Subsequently, many special tests were offered by various research laboratories in the interest of obtaining more funds for research in exchange for service.[1] The resulting situation is typified by the Toronto General Hospital where, in 1957, there were twenty-six small laboratories spread throughout the hospital and in the Banting Institute.[2] In the TGH, the Department of Laboratories has since provided a unifying force but many other North American hospitals have been left with a fragmented laboratory system and a resulting inability to deal with the volume of tests requested.

Table 1 presents data concerning an arbitrary selection of laboratory tests performed in the Toronto General Hospital (1,393 beds) in 1965. Brief examination of these figures will give some idea of the magnitude of the problem faced by the present day clinical laboratory.

Operations on this scale are possible in large measure because the hospital had sufficient foresight twenty years ago to plan for spatial consolidation and organizational co-ordination in their laboratory program. Separate divisions of Pathology, Hematology and Blood Transfusion, Microbiology and Chemistry are now administered by trained specialists who form an important part of the consultant team. It is the lot of such specialists to determine the manner in which new technological advances may be applied to the improvement of health services.

TABLE 1: LABORATORY TESTS
TORONTO GENERAL HOSPITAL 1965[3]

test	*times performed*
A) HEMATOLOGY	
Hemoglobin	86,029
Blood films	81,224
White Blood Cell Counts	49,573
Differential Counts	12,293
Sedimentation Rates	34,545
LE cell Preparations	7,190
Prothrombin Time	17,629
B) BACTERIOLOGY	
Blood Culture	6,707
Urine Culture	20,103
Stool Culture	2,419
Widal and Paul Bunnell	735
C) CHEMISTRY	
Complete Urinalysis	48,621
Serum Electrolytes	34,025
Blood Glucose	51,920
Blood Urea Nitrogen	51,945
Total Serum Proteins	7,158
Protein Electrophoresis	1,601
Acid Phosphatase	1,514
Alkaline Phosphatase	7,701
Serum Bilirubin (total)	6,085
Urine VMA	354
D) MISCELLANEOUS	
Electrocardiogram	20,815
Pulmonary Function	2,364

The two pilot studies which follow have been chosen for discussion because they offer some insight into possible future trends in clinical laboratory science.

TABLE 2: RESULTS OF MULTI CHANNEL CHEMICAL SCREENING TGH

Patients investigated	1010
Patients warranting further study	430
Patients followed up	95

NEW DIAGNOSIS

Number of Cases	*New Diagnosis*
11	Diabetes Mellitus
6	Urinary Tract Disease
2	Hepatobiliary Disease
1	Iron Deficiency Anemia
1	Hypoparathyroidism
1	Thyrotoxicosis
1	Gout
1	Asthma-Bronchitis
1	Periodontitis
1	Electrolyte Imbalance
1	Iatrogenic Hypokalemia

NEW FINDINGS

Number of Cases	*New Finding*
4	Hyperuricemia
2	Hypercholesterolemia
1	Iatrogenic Hypothyroidism
19	Irregular Antibody Formation
36	Positive VDRL
1	Possible Hyperparathyroidism
1	Possible Pancreatic Carcinoma

1: Multi Channel Chemical Screening
Toronto General Hospital[4]

Over a period of fourteen months, one thousand and ten patients were selected at random from the out-patient clinics of the Toronto General Hospital and given a series of twenty laboratory investigations regardless of diagnosis made or tests ordered by the examining physician. The doctor was informed only of results in those tests which he had ordered. When investigation and treatment were judged by the doctor to be complete the case was re-evaluated and the physician was shown the entire laboratory profile of his patient. In 430 out of 1010 cases the unordered tests revealed findings which, in the physicians opinion merited further investigation. Ninety-five patients were finally brought back to clinic and the conditions listed in Table 2 were revealed in follow-up studies.

The twenty-seven patients whose diagnoses were substantially altered as a result of the study represent thirty per cent of the ninety-five patients who were actually available for further investigation.

The important point in this study is the finding that that almost one out of every two patients involved had one or more laboratory tests lying within a suspicious range, when tests were done at random without the conventional indications. The implications of this are two-fold: firstly we must begin to suspect the "normal laboratory value" as an idealistic figure often having little meaning in reference to a specific patient; secondly we must question the diagnostic skill of the modern physician who is often impotent as a diagnostician without the aid of an extensive clinical laboratory. It seems that medical practitioners may soon be forced to forsake their classical duty of diagnosing full-blown disease states and turn instead to the prophylactic treatment of early disease as revealed by sophisticated screening procedures. Perhaps the future doctor will find a greater satisfaction in the development of an ability to tell which "abnormal" values are truly abnormal for a specific patient.

2. Multiphasic Health Testing—
Kaiser Foundation, San Francisco[5]

In a current program conducted since 1964 at two two hospitals of the Kaiser Foundation Health Plan in San Francisco, more than four thousand patients monthly are undergoing comprehensive health evaluation. These patients are exposed to a battery of fifty screening procedures as they move between twenty test stations over a three hour period (Tables 3 and 4). Information from most of the stations is fed into computers during the test period so that an "advice printout" is available at the final station to recommend additional tests before the physical examination. If a serious abnormality shows up in any test, the patient is sent immediately to a clinic for medical consultation. The computer finally processes all the data including medical interpretations of cardiograms, X-rays and retinal photographs and prints out a summary of this information, available to the physician during his physical examination.

The program aims to predict and consequently prevent illness and to study the effects of early diagnosis on morbidity and hospital utilization. The computer is programmed to search for combinations of slight abnormalities that may be an early warning of symptomatic disease.

Detailed figures are not yet available for the Kaiser Foundation study, but early findings have already established new norms for all groups in all areas tested and this should permit more meaningful computer programming in the future. The value of mammography in women over 45 has also been convincingly demonstrated. (no supporting figures available).

Plans are now underway in California to expand this program using larger computers, a wider range of biochemical tests and longer hours of operation. A similar battery of tests may soon become a preadmission routine for most hospitals.

TABLE 3: KAISER FOUNDATION MULTIPHASIC HEALTH TESTING

Station	*Procedure or Measurement*
1	medical history questionnaire
2	disrobing
3	electro and phono-cardiograms
4	beginning of glucose tolerance test
5	anthropometry
6	chest X-ray
7	mammography
8	table tilt cardiovascular testing
9	visual acuity and pupillary escape
10	ocular tonometry
11	vital capacity
12	pain threshold
13	audiometry
14	"disease" questionnaire
15	tetanus booster
16	Hematology and serology
17	urinalysis
18	completion of questionnaires
19	photo of right retina
20	psychological testing

TABLE 4: HEMATOLOGICAL-SEROLOGICAL TESTS (Station 16)

Hemoglobin White blood cell count VDRL latex fixation Glucose Creatinine Albumin Total Protein Cholesterol Uric Acid Calcium SGOT	Performed in twelve minutes on two ml. sample by multichannel autoanalyzer

CONCLUSION

It is evident that a time has come when we must re-evaluate our clinical laboratory programmes and redefine the role of laboratory medicine in medical care and in preventive medicine. Hospital laboratories must first be unified both geographically within the hospital and functionally through the leadership of trained clinical pathologists assisted by specialist directors of various subdivisions. Once hospital laboratories have achieved a coherent programme with realistic allowances for teaching, service and research, we can better foresee the nature of their future service.

Improved data processing and biochemical analysis techniques are bringing us rapidly to the point where it will be far more realistic and economical to do a complete "profile" on each patient rather than perform an arbitrary selection of tests. The old diagnostician coupling wisdom and intuition may have a regrettably limited future but it is hopefully suggested by some sources[4] that widespread application of the techniques described will impose greater discipline on the thought processes of the medical profession and force the realization that "normal values" can only be applied to individual patients on a probability basis. By forcing an acceptance of uncertainty in medical practice, the new technology may thus succeed in forcing the physician once again into the view of himself as a practitioner of the *art* of medicine.

The words of Tennyson as mouthed by Ulysses seem particularly apt in their application to the evolving clinical laboratory:

> "All experience is an arch wherethrough,
> Gleams that untravell'd world whose margins fade,
> Forever and forever when I move."

REFERENCES

1. Seligson, D.: Mod. Hosp.: 106:5 109-113, May '66.
2. Young, D. M.: Canadian Hospital: 40: 52-3, May '63.
3. Young, D. M.: personal communication (unpublished figures).
4. Young, D. M.: paper presented to American Medical Association and American Society of Clinical Pathologists. Chicago, June 29, 1966.
5. Drossel, M. R.: Mod. Hosp.: 106:5, 113-116, May '66.

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THE PRESENT USES OF COMPUTERS IN MEDICINE

There has been extensive use of computers in business and the physical sciences. One reason for the rather late involvement of medicine with computers may lie in the belief that medicine is more of an art than a science and the earliest applications of computers were primarily mathematically oriented to the solution of non-medical research problems. In medicine the use of computers has been primarily in the solution of biomedical research problems. Lately, however, the widening non-mathematical application of computers in other fields has resulted in a reappraisal of the role of computers in medicine. It is likely that the future will see extensive computer applications in non-research problem areas in general medicine.

Computers are presently being used for hospital administration, biomedical research and patient care.

a) COMPUTERS IN HOSPITAL ADMINISTRATION

In hospital administration computers are used mainly for accounting and planning. The accounting uses include all data processing tasks related to the upkeep of records on patients, inventories, accounts and payrolls. These, essentially routine functions, are in no way specific to the administration of medicine and have been well documented in business usage. The planning uses of computers include both short-term and long-term projects. Short-term projects encompass such activities as the preparation of staff timetables, the scheduling of bed occupancy in hospitals, and the rational allocation of laboratories and equipment. Long-term planning involves such activities as the collection of sufficient data and their integration for the purpose of making projections of requirements for staff, facilities and budgetary provisions to meet a variety of service commitments and contingencies.

b) COMPUTERS IN BIOMEDICAL RESEARCH

In the area of biomedical research, computers are used in the analysis and simulation of biological systems, in the routine processing of biomedical data, in the process control or monitoring of complex laboratory experiments, and as tools for the retrieval of published research in scientific journals and reports.

c) COMPUTERS IN PATIENT CARE

The use of computers in patient care occurs in two different modes described in the jargon of computers as *batch processing* and *real-time processing*. These two operating modes are distinguished by the fact that in real-time, data in the form of signals collected from a particular process is used continuously to adapt and modify the process,* whereas in batch processing there is no immediate urgency involved and data can be accumulated and similar problems can be grouped in batches for processing efficiency. In some situations, there may be a time limit such that certain batches of data are processed within a certain number of minutes or hours after entering the system. Examples of batch processing include:

(1) The calculation of radiation dosages.

(2) The processing of drug orders.

(3) The ordering and reporting of laboratory tests.

The most important example of real-time processing is the use of computers in the monitoring of critically ill patients. This implies that the feedback loop involved must permit messages to be transmitted almost immediately (usually within two or three seconds) after a stimulus event has indicated that immediate corrective action is indicated.

(i) Computer Calculation of Radiation Dosages

". . . A given treatment is most easily evaluated by preparing a chart which shows, on a cross section of the patient, the distribution of radiation dose in the form of "contours" of equal radiation dose, or isodose curves. Such charts are usually prepared by

**The common reflex arc is an example of real-time process in a biological system.*

graphically combining known curves for single fields. This involves considerable manual labor by trained personnel and is seldom done except in large institutions, and even then for only a small proportion of the patients, with perahps one or two treatments being plotted for each patient." [1]

Using a computer, treatment can be designed specifically for individual patients and the optimum one chosen from several alternative plans. The computer's ability to perform tedious calculations requiring many hours if done manually make alternate treatment plans feasible. The computer can determine for specific treatment situations those conditions which will lead to the highest dose to the tumor and the smallest dose to normal tissues.[2]

(ii) Computer-Based Processing of Drug Orders

Baruch and Barnett[3] at the Massachusetts General Hospital have been experimenting with a computer-based clinical administration system. The following quotation describes that portion of the system dealing with the processing of drug orders:

". . . one of the difficulties we have in the hospital is that many of the drugs have rather complicated spellings. To make sure that drug orders are correctly entered, we check drug name against a formulary. If no exact match is found, the person operating the Teletype is presented with a list of drugs having similar sounding names and requested to choose the desired one. In addition, we take advantage of the fact that many drugs have a dose limit which is rarely exceeded, and check all orders against dose limit. If, because of error in interpretation of an order, or because of error in remembering the proper dosage, a quantity of drug larger than this limit is specified, the computer returns with the information that this is an unusually large dose and requests a specific confirmation of the order. Also, many drugs can be given only by a specific route, such as intravenously, or by mouth. By checking the route of each prescription item the program assures that the order is valid in this regard."

The system has built in an elaborate system of safety checks which permit increased safety in the handling of medications of all kinds.

(iii) Computer-Based Reporting of Laboratory Tests

In a typical hospital today, more than 500 laboratory tests are conducted daily and each must be scheduled, recorded and reported in a variety of forms. These laboratory tests are usually ordered for specific patients on specific dates by specific physicians. For meaningful presentation to the physician, however, it is important that the results of the test be displayed in the most meaningful manner. The flexibility of a computer-based laboratory control system permits a variety of display formats to be prepared depending upon local circumstances. An example of one of these forms is illustrated in Figure 1 which reflects some of the techniques being developed in their experimental medical records system at the Roswell Park Memorial Institute.

(iv) Computer Monitoring of Critically Ill Patients

Of prime importance in the care of critically ill patients is the need to make quick and safe decisions. In this regard pathophysiological changes which occur rapidly, but may be of extremely short duration, require almost continuous monitoring if effective treatment is to be effective. Current studies investigating the possibility of computer monitoring of patients include the automatic computation of fluid and electrolyte balance[4] and the automatic control of potent drugs used in the treatment of patients in shock.[5]

In the latter study a shock research unit was set up at the Los Angeles County General Hospital as a research ward to investigate the care of critically ill patients in circulatory shock. The primary goal of this unit was to improve the care of the critically ill patient. A second

Figure 1. CUMULATIVE LABORATORY REPORT

WARD 400 NAME ..... March 17, 1966

URINE	*Color*	*Reaction*	*Sp. Gr.*	*Alb.*	*Sugar*	*Acet.*	*WBC*	*RBC*
12-8	Y	7	1.019	0	0	0	1-2	0
12-7	Y	8	1.012	0	0	0	6-8	0
12-6	Y	8	1.010	0	0	0	35-40	0
12-5	Y	7	1.030	0	0	0	32-35	0
12-3	Y	6	1.015	0	0	0	35-45	0
12-2	Y	6	1.018	0	0	0	1-2	0
12-2	Y	5	1.018	0	0	0	8-10	0
12-2	Y	5	1.028	0	0	0	6-8	0
12-1	Y	7	1.019	0	0	0	1-2	0

objective was to gather data for later de post facto fundamental research. A third objective was to use computer-assisted techniques to augment the abilities of highly trained medical personnel so that skills in short supply could be extended to benefit additional patients without reducing the overall quality of patient care.

The following quotation describes the essential features of this experimental facility:

> "Normally the computer reads sensor data, reduces it and logs it out every five minutes on a typewriter in the ward. However, if any of the measurements fall outside the bounds preset by the physician for an individual patient, these measurements are printed out in red. For certain critical variables, this can serve as a flag to the physician, nurse or lab technician to cause the computer to monitor continuously, rather than on the regular pre-programmed fixed cycle."
>
> * * *
>
> "The Shock Research Unit is already contemplating closing the loop and using the computer in a control capacity. Some of the potent drugs used in the treatment of the patient in shock are administered by infusion pumps which are manually monitored and controlled by medical personnel. Careful observation of the response to these potent drugs is mandatory, for inappropriate doses may have disastrous consequences. It may be possible to put these pumps under direct computer control with manual override, and maintain a desired level of blood pressure or blood flow.
>
> With the computer appropriately installed and programmed, highly trained medical personnel can render more effective care to a larger number of patients. They can direct their attention to the critically ill patient, leaving routine monitoring and mechanical chores to lesser trained medical personnel and the computer.[6] "

THE FUTURE USES OF COMPUTERS IN MEDICINE

Computers may be used for pedagogical purposes, as an aid in differential diagnosis, and as the basis for large-scale medical information systems.

a) COMPUTERS IN TEACHING

The uses of computers as a pedagogical tool will embrace many activities. At the undergraduate level computers may be used as teaching machines (e.g., the teaching of diagnostic decision making) using programmed instruction materials, and as processing units in the marking and analysis of objective tests used to evaluate student progress. Because computers will be increasingly used for the maintenance of data on patients (history, symptoms, treatment, etc.) and for the storing of medical information (current information concerning logical relations, probability determinations and value considerations on disease-symptom-treatment relations), undergraduates and graduate students will require instruction in the utilization of computing machines in such advanced information storage and retrieval systems. This training will also be essential for the continuing education of the practicing physician, who will also require such competence for the use of these systems in day-to-day diagnostic and therapeutic problem solving.

b) COMPUTER-ASSISTED DIFFERENTIAL DIAGNOSIS

Diagnostic systems have been proposed in which the computer is used for the processing of physiological signs, symptoms and laboratory results. These methods require that a vast amount of information be stored in the computer's memory, in the form of symptoms correlated with the correct diagnostic classification. This method ignores the probabilistic occurrence of symptoms and their associated diseases and simply assumes that a sign or symptom is either present or not in a particular disease. Since different patients who have a particular disease rarely present an identical pattern of symptoms, the combinations that are stored in computer memory represent textbook cases that rarely appear in practice.

In a more sophisticated approach, Ledley and Lusted[7] have proposed a scheme in which symptoms and diseases are formalized in terms of symbolic logic, probability theory and value theory. Their computerized system processes combinations of symptoms and signs which are associated with certain specific diseases and prints out several likely diagnoses.

Diagnosis, the process by which the physician devises a course of treatment, cannot be taken over by the computer. Diagnoses are not always formed at any given point in time. Frequently the physician forms intermittent diagnoses on which he bases treatment, the response to which may indicate a change in diagnosis. This recursive nature of the diagnostic process therefore precludes the possibility of computers being substituted for physicians. An experienced diagnostician is able to select from among the wealth of the data that each clinical case offers him. The criteria for his choice of data are many and complex in their interrelationships and are arranged in a hierarchy many layers in depth. The analysis of relationships in depth is not particularly suited to computer manipulation and even when it can be accomplished requires inordinate amounts of computer time which would be reflected in cost. In addition, the possible number of permutations and combinations of symptoms and diseases are simply so large that present-day computers could not economically evaluate them all.

The contribution of the computer will lie in its ability to process clinical information rather than to make decisions concerning diagnostic or treatment possibilities. Computers do have the ability to perform dis-

criminatory operations on some types of data with greater precision than can be accomplished visually. For an example of the ability of the computer to assist in the processing of such data, see Caceres' article[8] which describes computer analysis of electrocardiograms, phono-cardiograms and electroencephalograms. Caceres takes the position that computers can be of tangible assistance to physicians in automatically extracting, by pattern recognition techniques, all necessary pertinent data from medical signals for clinical interpretation purposes.

> "Medical signals are used by all physicians as part of their routine diagnostic efforts in patient care. The signals must be interpreted by a physician. Interpretation requires a specialist with many years of training because of the complexity of the signals and and the myriad nature of the patterns that are seen. These signals are generally recorded from different body locations by appropriate placement of electrodes and appropriate circuitry to tell us about heart function, brain function, lung function, muscle function."

The reading and interpretation of large numbers of signals is a routine and time-consuming task for the physician. A completely automated system to aid the physician in this task is described by Caceres.

c) COMPUTER-BASED MEDICAL INFORMATION SYSTEMS

Medical information systems will serve two quite different functions: the information needs of physicians with respect to current developments in diagnostic and therapeutic techniques on the one hand, and the medical records of patients on the other hand. It is possible that the same equipment as far as computers and data transmission devices will provide both services, but in the development stages, separate facilities will be used.

(i) Computer-Based Information Retrieval Systems

The primary role of the physician is to devise treatments for individual patients. With expanding patient loads, the individual physician will find it increasingly difficult to keep abreast of the most current research concerning specific disease entities, diagnostic innovations and therapeutic procedures. This information lag will be further compounded by the inadequacy of present systems to direct the attention of individual physicians to medical advances appropriate to their specific needs. Moreover, any one physician may during his entire practice require only a small portion of the total knowledge available. An information retrieval system could automatically make available to the individual practicing physician the most current information he requires in the most usable form. Existing information retrieval systems such as the MEDARS (Medical Literature Analysis and Retrieval System), producer of the Index Medicus, are primarily oriented toward the medical researcher and are general rather than specific in nature. Furthermore, systems such as this are undiscriminating as far as the particular interests of clinical specialists are concerned.

(ii) Computer-Based Medical Record Systems

With increasing mobility of population in the next few years, requirements for adequate health care will demand well designed and smoothly functioning medical record systems. An adequately organized local, regional and national records system could insure that a person's medical record is made available quickly, if needed, although he may have moved recently or is traveling far from home.

A computer-based information processing system could make a large collection of clinical data accessible to scientific investigators. The medical records should be a collection of data to which analytic techniques may be applied and from which scientific conclusions may be reached concerning disease-symptom-treatment logical relations, trends in the incidence of infectious disease and unsuspected toxicities of experimental or established therapeutic measures.

Automation of medical records will not be a simple, straightforward task due to the characteristics of the information itself. Since different clinical interests impose different requirements, records must be variable in depth and breadth. Scientific and clinical requirements will likely impose two diverse processing methods on the system instead of one as in most information systems. Record requirements in clinical medicine vary widely according to the type of record involved. Laboratory reports may be structured and concise, whereas clinical histories and physical examinations tend to be unstructured and lengthy.

An experimental medical records system is currently being developed at Roswell Park Memorial Institute. Their system is designed to provide a laboratory for experimentation in the handling of clinical data by computer, and the establishment of the medical value of automatic collection, organization, storage, and presentation of clinical data.[9]

A second experimental record system is being investigated at the Institute of Living.[10] It is intended that this system will:

(1) Provide a far more efficient means of recording and communicating patient information. The standardized reporting system will reduce the confusion of meaning so prevalent in psychiatry today.

(2) Develop techniques for more accurate evaluation of patient progress and, hopefully, lead to the development of a means for predicting treatment success across the broad spectrum of hospital patients.

(3) Reduce the burden associated with hospital administrative procedures and thereby free professional personnel for more direct patient contact.

(4) Increase the efficiency and safety of the logistics for patient care. This includes the ordering and administration of medication, food service, scheduling patient activities, and extending patient privileges.

(5) Improve statistical reporting procedures by capturing significant data on all patients. This will make a superior data base available for clinical and research uses.

Part of the activities of the Institute of Living have resulted in the design of standard report forms which enable patients' data to be quickly entered automatically into the computer system.

CONCLUSION

There has been extensive use of computers in medicine in the United States at such centers as the National Biomedical Research Foundation, Johns Hopkins University, the Division of Biostatistics in the School of Medicine at the University of California at Los Angeles, the College of Medicine, University of Cincinnati, and the National Institutes of Health, Bethesda, Maryland. Except for isolated applications, there has been very little coordinated use of computers in medicine in Canada.

The potential application of computers in medicine cannot be ignored. Their role, however, will be similar to other instruments that have been developed to increase the powers of man. Whereas a microscope increases visual capacities, the computer expands the power of the brain, especially in those areas where a vast memory for facts is required or where tedious, time-consuming and boring calculations have to be made. The important thing is that the physician be in a position to maintain authority and control over the use of computing equipment in the same way that he does over other equipment. In order to be able to do this, physicians must become familiar at least in broad terms with the strength and weaknesses of computing machines.

REFERENCES

1. Siler, W., Ritter, F. and Laughlin, J. S.: Patient Simulation in X-Ray Therapy. Annals of New York Academy of Sciences, 115: 1038-1048, 1964.
2. Perry, Harold: "Automation of Radiation Treatment Planning", In Computers and the Life Sciences, by Sterling, T. D. and Pollack, S. V. Columbia University Press, 1965.
3. Baruch, Dr. J. J. and Barnett, Dr. G. O.: Joint Venture at Massachusetts General. Datamation, December 1965.
4. Vallbona, C., Spencer, W. A., Geddes, L. A., Blose, W. F. and Canzoneri, J. Experience with On-Line Monitoring in Critical Illness. IEEE Spectrum, September 1966.
5. Patrick, R. L. and Rockwell, M. A.: Patients On-Line. Datamation, September 1965.
6. Ibid., pp. 57-60.
7. Ledley, R. S. and Lusted, L. B.: The Role of Computers in Medical Diagnosis. Med. Dok., 5: 70-78, 1961.
8. Caceres, C. A.: Computer Analysis of Medical Signals. Datamation, December 1965.
9. Ausman, R. K., Baer, G. D., McGuire, M. R., Marks, R. A., Ewart, R., Carey J. and West, R. L.: Clinical Data Management. Annals of New York Academy of Sciences, 128: 1100-1107.
10. Glueck, Dr. B. C.: Computer Techniques in Patient Care. The Institute of Living, Hartford, Connecticut.

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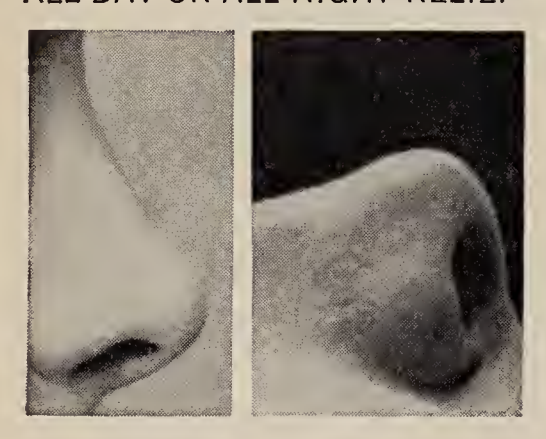

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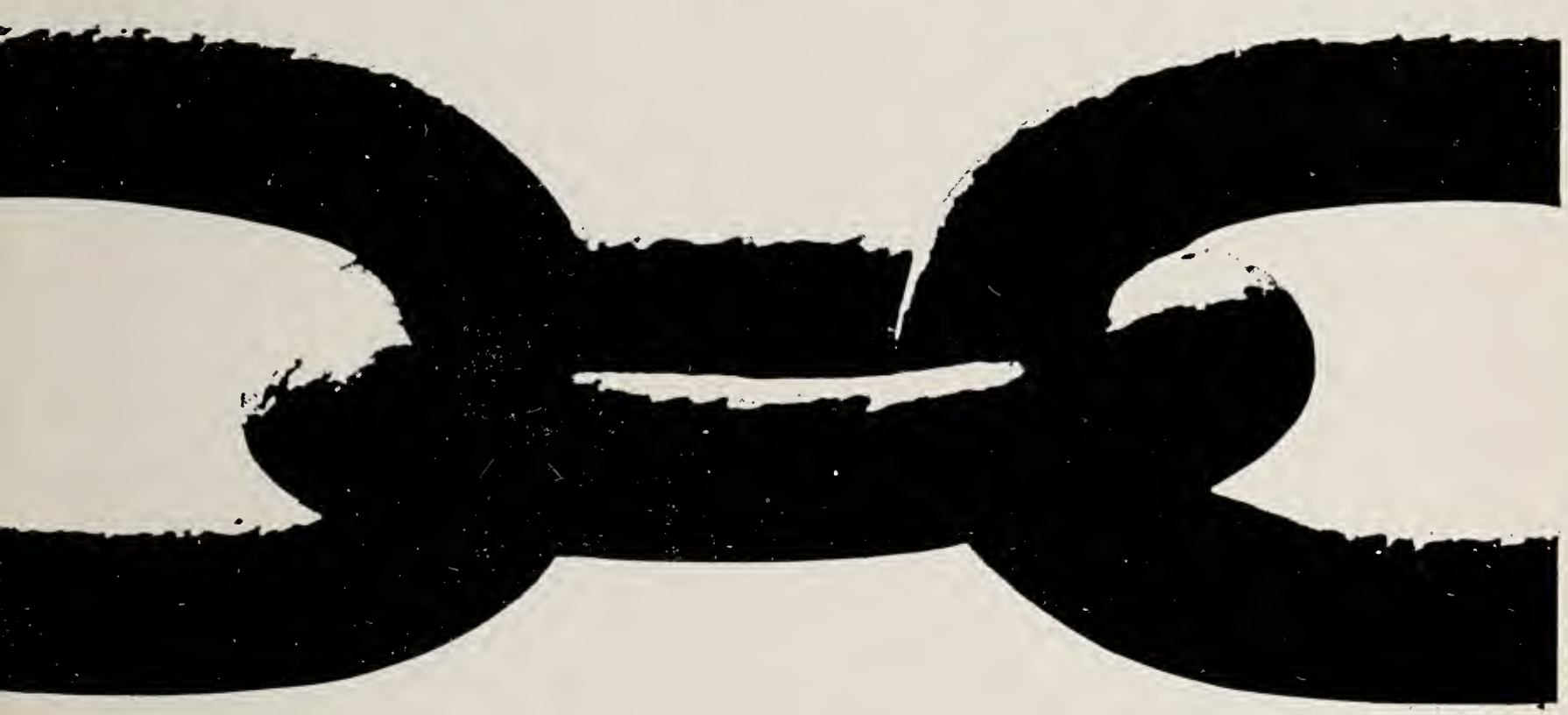

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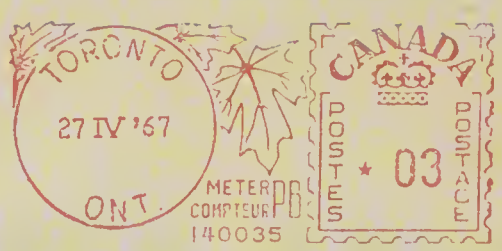

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